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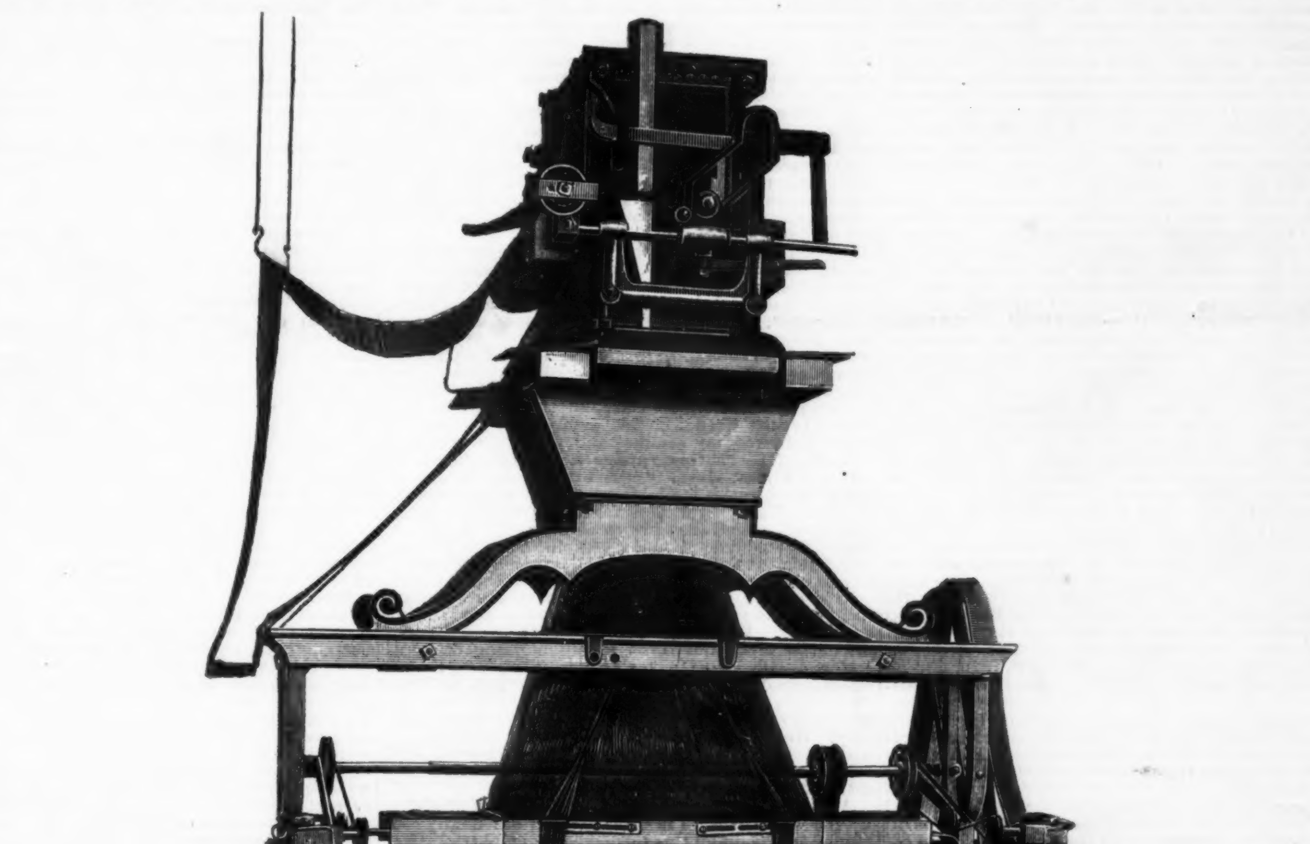
IMPROVED LOOM FOR WEAVING HORSE-HAIR.

AMONG the interesting works opened to the members of the Institution of Mechanical Engineers at their recent meeting were those of Messrs. Samuel Laycock & Sons, Portobello Place. They are devoted to the manufacture of horsehair cloth and curled hair for stuffing cushions. It is the preparation of the former that is of the greatest interest to mechanical engineers, as it involves the use of a loom which will be doubtless quite novel to the majority of makers and users of textile machinery. When it is remembered that weft of horsehair cloth cannot, in the most extreme cases, be above 5 ft. in length, that the material is extremely hard and elastic, and that each filament is considerably thicker at one end than the other, it will easily be seen that the designer of a loom to weave such material with rapidity and success has no easy task set for him. These difficulties have, however, been overcome by Mr. W. S. Laycock, and the combination of ingenious devices which he has originated has resulted in the production at a moderate price of that beautiful semi-transparent fabric which supplies an ideal material for the sunblinds of railway carriages, steamships, etc., as it admits of sufficient light without the glare of sunshine. When these blinds are dyed a bright amber color, as in the case for instance of those on the White Star steamers Majestic and Teutonic, the result is especially pleasing; the effect being that of a diffused and mild sunlight. The weft of this cloth is of horsehair, while the warp is of cotton or flax. The warp, however, is buried in the hair, so that it does not show in the finished material. The horses' tails come chiefly from South America and Siberia. In the former place horses are slaughtered in large numbers, every bit of



IMPROVED LOOM FOR WEAVING HORSEHAIR CLOTH.

the carcass being used for some purpose. The flesh is ground up into manure (so it is said), some of the bones follow the same course, while others are used for turning, etc. The hide is made into leather, the hoofs into glue, and finally the tails and manes into hair cloth or "curled hair," with which to stuff cushions. The longest hair of which Messrs. Laycock have record is 6 ft., but such a specimen is extremely rare. The tails, as they arrive from abroad, are in a very untidy state, being just mops of hair, generally plentifully interwoven with burrs. These tails have to be carefully combed out and washed, after which the various lengths are sorted out by hand. The next process is bleaching, unless it is intended to weave the cloth in natural colors. It is a fact that there is considerable difference between horsehair that has been cut from the animal while alive or immediately after being killed and that which has been taken from the beast when it has been dead some time. In the latter case the hair is dull and opaque, while in the former it retains its transparent and glossy appearance. Some of the bundles of selected white hair that Messrs. Laycock have form really beautiful objects when tied tightly together, looking more like batons of a transparent ivory than wisps of hair.

The next process is to dye the hair, when an artificially colored material is required. There are, we believe, many secrets in connection with this art; and as the trade is in few hands, they appear to be well kept. It requires a very different mode of procedure to dye horsehair to that followed with other materials, even wools and other kinds of hair, and there are more than ordinary difficulties in the way. In the case of Messrs. Laycock these difficulties appear to have been overcome, as they produce fabrics containing blues, reds, greens, and yellows of apparently all shades.

There are still at these works a large number of old styles of hand looms for weaving hair cloth. These looms are each operated by two women, one "serving" the hair while the other draws it through the warp. The very ingenious loom which has superseded this primitive contrivance is illustrated on the first page of the present number. The bundles of hair are placed in two troughs, one on each side of the loom, all the thick ends being arranged to lie together. In connection with each trough is a selecting instrument which descends, and by means of a spring gripping device takes a hair from the bunch and holds it in position until it is taken by the shuttle. It is necessary that this gripper should let go the hair at the right instant of time, not too soon, as in that case the hair would be dropped, while if it held on too long the hair would be dragged through the jaws of the catch, the result being that they would last but a very short time. The most curious feature about the selecting instrument is that should it fail to secure its hair at the first try, it will make another effort; and if still unsuccessful, yet a third. Nothing in the way of mechanism could be more intelligent. The selecter does even more than this. Should it not get a hair to present to the shuttle upon the third attempt, it puts in action the weft stop motion, which prevents the shed from changing, and stops the left-off and take-up motion. The selecter on the opposite side then presents its hair in turn, and no imperfection in the fabric results. Some of the Waltham watch machinery, and of the Singer Sewing Machine Company's machinery appears almost intellectual in its automatism, but Mr. Laycock's selecter affords an object lesson of high moral attributes. The way in which it recognizes it has failed, and at once proceeds to try again and again without discouragement, and then when there is no longer hope that it can succeed itself—for the impatient shuttle never waits for a fourth attempt—giving its partner on the opposite side an opportunity to repair the fault, might be laid to heart by many with advantage. The shuttle itself has jaws to grip the hair, taking hold and letting go just at the right instant.

It would be manifestly impossible to describe how these motions are carried out without the aid of elaborate illustrations. Horsehair cloth is woven from 14 in. up to 36 in. in width.

The preparation of curled hair is comparatively a simple matter. The hair after washing is carded and then spun into ropes so as to give it the kink or curl which affords the springiness necessary to a comfortable cushion.

It may be stated that Messrs. Laycock work up from 15 to 20 tons of horsehair per week.—*Engineering.*

HISTORY OF THE INDIA RUBBER INDUSTRY.

The scarcity of existing copies of a small pamphlet issued by the late Nathaniel Hayward, and the interest attaching to the history of rubber processes, are deemed, says the *India Rubber World*, sufficient reasons for reproducing the work in full. The title runs:

SOME ACCOUNT

OF

NATHANIEL HAYWARD'S

EXPERIMENTS WITH INDIA RUBBER

WHICH RESULTED IN DISCOVERING THE

INVALUABLE COMPOUND

OF THAT ARTICLE

WITH SULPHUR.

NORWICH, CONN.:

BULLETIN JOB OFFICE, FRANKLIN SQUARE.

1865.

Inside the pamphlet begins:

STATEMENT.

Some time previous to the year 1834, there was a company formed at Roxbury, Mass., to manufacture India rubber goods. The members of this company were John Haskins, Edwin M. Chaffee, and Luke Baldwin. They had in some way learned the art of dissolving rubber gum, which they tried to keep a profound secret. They soon however, sold out their interest to a larger company called the Roxbury India Rubber Co., who continued the business in the same place. This company made large preparations to manufacture India rubber goods, and the interest got up with regard to this article in and around the city of Boston was very great. India rubber cloth for carriage tops, overcoats, and other articles to protect such as were obliged to be out in stormy weather, and it was thought would soon come into general use and create a great demand for this fabric.

In the year 1834, General Jackson, then President of the United States, visited New England, and while at Boston was presented with a suit of clothes of this new manufacture, in which dress, on a day somewhat wet, he appeared in public on horseback, for the purpose of reviewing the troops on the Boston Common. This occurrence helped to inflate the bubble, and in a short time the stock of this company rose from one hundred to five or six hundred dollars a share, and every one owning stock in this concern, it was thought, was about to make his fortune.

My curiosity, with that of many others, was highly excited, and I went to the factory, and bought rubber cloth for a carriage top. When using the carriage thus covered, I noticed that when two surfaces of this cloth came together, in a warm day, they adhered, in consequence of the softening of the gum. This struck me as quite an objection to the use of the article, and led me to try experiments to obviate it.

For this purpose, in the month of August, 1834, among other experiments, I mixed and melted together rubber gum, sulphur, and lampblack; but this mixture, at that time, did not result in anything valuable. I continued, however, as I had leisure, experimenting with this article from August, 1834, till April, 1835, showing from time to time small samples of my results to sundry persons engaged in the rubber business, for the purpose of carrying on which many companies were being formed in and around the city of Boston, where I then lived. I was assured, by persons to whom I showed my samples, if I could hit upon any method of preventing rubber cloth from becoming soft and sticky when it was exposed to the sun or otherwise warmed, I might depend on being well rewarded. These assurances from men in whom I had confidence encouraged me to continue my efforts. I, therefore, sold out my livery establishment in Boston, that I might be able to devote all my time and attention to the business of experimenting with India rubber.

After closing up my affairs, and paying my debts, I had remaining about five hundred dollars and a horse and buggy. With this property I went out to Easton, my native town, and hired a mill building of Cyrus Lathrop, called the Quaker Leonard Place, at a rent of one hundred and fifty dollars a year. This mill was situated in a retired spot, about half a mile from the main road, and not far from Oliver Ames' shovel factory. Here, remote from observation, I shut myself up and entered upon a course of experiments with rubber, and continued it for two months without any satisfactory result.

At the end of this time I was on the point of giving up the whole concern in utter despair, but finally concluded before doing this to make one more trial. For this purpose I put all my chemicals with which I had been working into a still of the capacity of fourteen or fifteen gallons, with spirts of turpentine, and drew off about four gallons, into which I put four pounds of rubber gum to be dissolved, and with this solution I made twelve yards (three-fourths wide) rubber cloth, which looked finely, and which stood the weather perfectly without melting when exposed to the sun for months. The chemicals I put into the still were white vitriol, blue vitriol, sugar of lead, sulphur, and several others, indeed, all I had. This result gave me much encouragement, and I took my rubber cloth and went to Boston, thinking that now I had found out how to make rubber goods that would stand the test.

I showed my cloth to a company recently formed, called the Eagle India Rubber Co., and they at once offered to give me employment. But I declined entering into their service till I had ascertained by further trial that I could make more cloth like the piece I had been exhibiting. I, therefore, bought a new supply of chemicals and returned to Easton to repeat the experiment which had proved so successful. To my great disappointment, after numerous trials, variously repeated and continued for nearly four months, I utterly failed to make anything like the sample I showed to the company in Boston. I then went to work to examine my chemicals separately, with the view of ascertaining their purity. I found impurities in many of them, especially spirits of turpentine and lampblack. The turpentine I found I could purify by thoroughly agitating it with water, and the lampblack by exposure to heat, and thus clearing it of all oily matters with which it is usually connected. The spirits of turpentine thus purified I found would dissolve the rubber, and purified lampblack being added and the solution applied to cloth produced an article which would stand the weather. Upon the strength of this discovery I engaged to work for this company on a salary of $1,000 a year. They carried on their business at Easton, and employed six or seven men and some twenty girls manufacturing ladies' aprons, carriage covers, and other articles, for about seven months. They then procured a new and more convenient building at Woburn, and began work there in April, 1836, and carried it on about eighteen months. All this time I was employed by this Eagle Company. Soon after they began work at Woburn they expressed the wish that I would make some white aprons, thinking they would sell well. This I attempted to do by using a compound of white lead, magnesia, and whiting, with equal parts of virgin or white rubber, dissolved in spirits of turpentine. The aprons looked pretty well, but when warmed would soften and stick, and not being white enough to suit me, I exposed them to the fumes of sulphur to make them whiter, taking the hint from having seen straw bonnets bleached in this manner. By this treatment the rubber cloth became very white, and made elegant aprons. But, in addition to superior whiteness, I noticed that these aprons did not soften and adhere after being exposed to the fumes of sulphur as they had done before such exposure. This gave me the first intimation of the power of sulphur to prevent rubber from becoming soft and adherent when warmed. After this I tried exposing pieces of cloth to the sun that had been fumigated with sulphur, and others of the same kind which had not been thus treated, and found the former would stand firm while the latter would melt and become sticky.

From this time I tried a great variety of experiments with these articles, in numerous and various combinations, and I found that when sulphur was one of the ingredients of the mixture, there was no melting or sticking of the rubber cloth. All the time I was working for the Eagle Company, and afterward, while working for myself, I, as I had leisure, was experimenting with sulphur and rubber, and the results and the way and manner they were brought about I kept entirely to myself. One of these discoveries was that rubber cloth which had been prepared without the use of sulphur, if sprinkled over with sulphur in powder and exposed to the sun, and afterward washed clean, that this process would fix the gum and prevent it from melting.

After I discovered that it was sulphur, and nothing else, among the articles with which I had been experimenting in combination with rubber, which prevented it from melting and becoming adhesive when warmed, it occurred to me that this was what made the piece of cloth shown to the Eagle Company free from the usual objections to this article as then made. But during the four months I was laboring in vain to make a perfect piece of rubber cloth, it never entered my mind that sulphur was of any account in this business, and I did not use it.

By the autumn of 1837 the rubber business was completely prostrated, as the goods made at the several factories did not satisfy the public, and most of the companies who had embarked in it wound up with the loss of their capital.

About this time, that is to say, in the fall of 1837, Hayward & Humphrey bought out the Eagle India Rubber Co., their stock and machinery, and carried on the rubber business together for about ten months.

In the spring of 1838 I began to carry on the business by myself, and continued to do so until September of the same year. In the month of July of this year, Charles Goodyear, whom I had previously seen in Boston, at his store, No. 12 Water Street, sent me an order to make him thirty yards of sheet rubber cloth a yard wide. I attempted to make this piece of cloth without using sulphur, lest he should detect its presence by the smell. I then made another piece, in the manufacture of which I used sulphur, which he pronounced very nice, and just what he wanted. From this piece of cloth Goodyear got the scent of the brimstone.

After I sold him, on the 11th of August, 1838, the piece of printing cloth with which he was so well pleased, Goodyear often called at my factory, but was not admitted, as I did not wish him to see my works, but I sold him several pieces of rubber cloth, after the first, which were made expressly for his use. At one of his visits to my factory, after sniffing at my cloth, he asked me if I used sulphur in the manufacture of my goods. I did not give him a direct answer, but waived the subject by remarking that its smell would be offensive. At a subsequent visit he said if I did not use sulphur he intended to get a patent for using it, as he had found out it worked well with rubber. I then told him the whole story of my using the article, and that I had kept the matter secret, as I intended to get a patent for it as soon as I got able.

On the 17th of September, 1838, I sold out my establishment to Charles Goodyear, agreed to work for him one year on a salary of $800, and immediately began my year's work.

It was agreed between us, early in the month of October, that I should have the necessary papers made out, send them to Washington, and obtain a patent in my own name, and then assign it to him. In consideration of such assignment he agreed to be at the expense of getting the patent in my name, pay me $100 down, give me his note for $900, due in six months, and give me the privilege of making three hundred yards of rubber cloth a day, until he should pay me the further sum of $2,000. When all this had been done, the whole benefit and interest of the sulphur patent was to belong to Goodyear—and all the papers pertaining to this contract were duly executed and delivered. Accordingly, the application for the patent was drawn up and sent to Washington, but owing to some informality, the papers were returned to be corrected. The correction was made and they were forwarded to the Patent Office a second time, but before the patent was obtained Goodyear came to me and said Doctor Jones, at Washington, advised him to take out the patent in his own name, to which, after some hesitation, I consented, provided such a course would not invalidate any part of our previous agreement, and he said certainly it would not. I then assigned to him my claim to a patent, on the 23d day of November, 1838.

Within the year, while I was working for Goodyear, I made goods of various colors, such as printing cloths for maps and globes.

In the month of January, February, or March, 1839, his brother, Amasa Goodyear, told me Charles had made a discovery, by means of which the rubber could be made to stand a higher degree of heat, saying, "You go and get a bit of cloth you made for him, and I will show you how it is done." I got him a piece, which he placed on the top of a hot cylinder stove, and it soon began to change color, grow darker, and finally turned to a slate color, when it underwent no further change, and was no longer affected by heat or cold—and all this without injuring the fiber of the cloth. This was at that time called heated or fireproof gum, but afterward vulcanized rubber. Charles Goodyear himself soon after told me he had made the discovery by putting a piece of rubber cloth on a hot cylinder stove. The cloth turned from a light to a dark color, and would then stand the heat or cold without any further change. He had done this with only small pieces of cloth, and found out no way of applying heat to a large surface to produce this change, while I was in his employ. From September 17, 1839, when my time with Goodyear was up, to April, 1841, I carried on business for myself. During this time I manufactured various

articles of rubber, some $1,000 worth, and put them into market, supposing I had a right under the contract with Goodyear to make three hundred yards of cloth per day. But on my offering my goods, I was notified by Luke Baldwin, of Boston, who had bought of Goodyear the right of using the sulphur patent for certain purposes, and if I sold my goods I should expose myself to a lawsuit, saying I had no right to make rubber goods, as I had conveyed all my rights to Charles Goodyear, and that he had offered Goodyear $20,000 for the entire sulphur patent. This interview with Baldwin took place in Boston.

On my return to Woburn, I called on Mr. Goodyear and told him of the conversation with Baldwin. He said he had not sold his patent to Baldwin, and that I could go on and make my three hundred yards per day of what goods I pleased and no one would molest me. Not feeling perfectly satisfied, I took my papers, went to Boston, and laid them before Willard Philips, an attorney somewhat versed in patent law. He told me my final assignment of the patent to Goodyear would annul the validity of the previous contract, and that it would be necessary to make a new contract with him to get the benefit of the three hundred yards a day. A few months afterward I made an arrangement with Goodyear which was satisfactory.

On the 3d day of April, 1841, I again sold out to Charles Goodyear, and agreed to work for one year from date.

From September, 1839, to April, 1841, Goodyear was in no regular business, but moving about from place to place.

In the course of the year 1841, while I was in his employ, Goodyear tried many experiments to perfect the heated gum process, so as to make it practically useful, but he did not succeed. In that year he made arrangements with Rider & Brothers, of New York, to furnish him with money to carry on his business. I stayed with him till April, 1842, when I took the factory into my own hands again, and carried on business on my own account.

In 1842, Goodyear carried on his rubber business in Springfield, and also in Northampton, Roxbury and Lynn; in all these places trying to perfect the heating gum process, and make it useful—manufacturing quite a variety of articles.

I carried on business on my own account from April 1, 1842, to the 22d of August, 1845. In that time I made for Mr. Goodyear several hundred pounds of fireproof sheet rubber, which was sent to Springfield and cut up into suspender threads, to make shirred suspenders, so called. I had then so far perfected the process as to heat a sheet of rubber cloth thirty yards long at one operation. My furnace and apparatus to do this were invented by myself, and kept secret.

At that time Mr. Goodyear was owing me considerable sums of money on back arrearages, which he was either unable or unwilling to pay. My finances were quite low, so low that my property was levied upon, and sold to pay taxes. While thus embarrassed, Goodyear told me if I would inform him how I compounded my articles, and the exact proportions, he could then get all the money he wanted, and would pay up all he owed me—a promise which he never fully performed. In this manner I was prevailed on to give him all the information he desired. With the knowledge thus obtained, his operations at Springfield were greatly improved.

As early as 1843, Goodyear sold the right of making rubber shoes to a company in New Haven, of which Leverett Candee and —— Steele were members. About this time Benjamin Coburn, who had been in my employment, was in New Haven, and I think working for Goodyear, who was exhibiting various small samples of rubber cloth to sundry persons, and among others, he showed them to Candee and Steele as his own manufacture. Coburn told these men that the samples with which he was making so much parade were not made by Goodyear himself but by one Hayward, in Woburn, who knew more about rubber in half an hour than Goodyear in all his life. This information from Coburn quite surprised them, as they did not suppose anybody knew anything about rubber except Charles Goodyear.

In consequence of this information of Coburn, I think in the month of April, 1843, he came to my place in Woburn to see me, and there found that what Coburn had stated was true. He asked me if I could make a shoe out of this fireproof or heated gum. I told him I thought I could. He told me if I could make a perfect shoe of this material, he would buy out my establishment at Woburn, and give me employment at good wages. Thus encouraged I told him I would go to work, and when I had succeeded, would let him know it. I accordingly spent something like three months in perfecting my apparatus, and experimenting with rubber, in the course of which time I accomplished my object. I put into my heater thirty pairs of shoes, and they came out perfect. I sent Mr. Candee five pairs as a sample, and informed him I was now ready to engage in the manufacture of rubber shoes. He came at once to Woburn, bought me out, and engaged my services for one year. I went on to Hampden, where his factory was, and began making rubber shoes. They were all right, except in one particular. They in a little time turned light colored. This I found I could obviate by using a smaller proportion of sulphur than is specified in Goodyear's patent. This prevented the shoes from blooming or turning white. I worked for this company through the year and made perfect shoes.

After this I went to Lisbon, Conn., and set up the business of making rubber shoes on my own account, in connection with Henry Burr. Our business was very prosperous, and while there, I discovered the method of giving our shoes a high polish. This was kept secret for some two years, and gave us great advantage over other companies in the sale of our goods. We carried on our operations in Lisbon from the autumn of 1844 very profitably till the spring of 1847, when we sold out to a joint stock company formed in the town of Colchester, Conn., called the Hayward Rubber Company, in which I still hold an interest, and in which place I now reside.

NATHANIEL HAYWARD.

Colchester, Conn., December 27, 1864.

STATE OF CONNECTICUT, } ss., Colchester, Dec. 28,
New London County. } A. D. 1864.

Personally appeared, Nathaniel Hayward, whose name is annexed to the foregoing statement of facts and observations, and made solemn oath that the same are true, according to his best knowledge and belief.

Before me, JOSEPH N. ADAMS,
Justice of the Peace.

AURIFEROUS EXPLOITATIONS OF THE DISTRICT OF BOGOSLOWSK (URAL).

THE district of Bogoslowsk, situated upon the east side of the Ural, in 60° N. lat., occupies a superficies of about 870,000 acres, and contains large mines of gold and copper.

It was during a missionary trip made in 1888 that we visited the great exploitations of auriferous alluvions formed there. It is often imagined that the Ural is a high range of mountains forming an insuperable barrier between Europe and Asia, but such is not the case. Of high summits there are scarcely any seen. The most elevated points reach from 5,600 to 6,200 feet, and this again is a rarity. The relief of the country rather consists of a series of hills or of slightly undulating plateaux running with an easy slope toward the plains of Russia or Siberia. The region is furrowed by numerous rivers whose yellow waters flow slowly between banks that are almost always high. But the general slope of the earth is sometimes so slight that the water cannot flow. The forests are very swampy, and it often happens that roads cannot be established unless they are formed of wood.

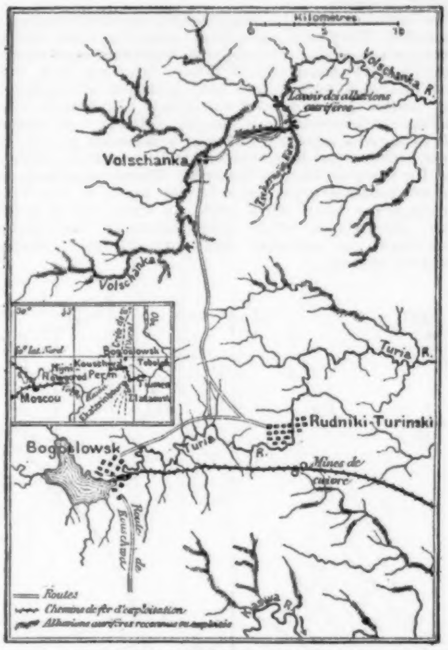


FIG. 1.—MAP OF THE BOGOSLOWSK GOLD DISTRICT.

Scarcely anything is exploited in the Ural but auriferous alluvions. The only deposits or placers where ores are extracted are those of Berezowsk, in the vicinity of Ekaterinbourg, and those of Miask, more to the south, near Zlataoust. The auriferous alluvions that are found in the beds of nearly all the streams of the east side of the Ural are from 3 to 6 feet in thickness. They always contain large pebbles of syenite, diorite, diabase or serpentine, among which are sometimes met with rolled pieces of rock crystal of perfect limpidity. The nuggets of gold are of very variable size. At the St. Petersburg School of Mines one may be seen as large as one's head and weighing 66 lb. But, in general, they are always small, and resemble grains of sand more or less fine.

The gold is almost always accompanied with platinum, but in quite small proportion. It is only in the vicinity of Nijni Tagnil that the alluvions rich in platinum are worked. With this metal there is found, in general, iridium, osmium, and rathenium. The scales of osmiuret of iridium, which are the most abundant, are recognized everywhere by their crystalline aspect and their smooth and brilliant faces. They in no respect resemble the dull grains of platinum.

The age of these alluvions is easy to determine. We find in them the *Rhinoceros tichorinus*, *Bos primigenius* and *Elephas primigenius*.

The proportion of gold in the alluvions varies between 12 and 22 grains per ton. It is only exceptionally that it reaches 30 and 45 grains.

The auriferous exploitations of the district of Bogoslowsk are nearly all concentrated in the basin of the Volschanka. The large installations and most important working points are situated upon the banks of one of its small affluents, the Tshernoia Rieva ("black river").

The search for auriferous sand and the determination of its yield in gold was conducted in the following way:

On a series of lines at right angles with the course of the stream, wells five feet square were sunk to the bed of auriferous alluvion. This latter was always met with at a depth of from 6 to 12 feet, at least, in the central part of the valley. The wells of the same series are spread from 25 to 30 feet apart. The largest of each row varies between 190 and 250 feet. Finally, the distance between the rows is from 160 to 320 feet.

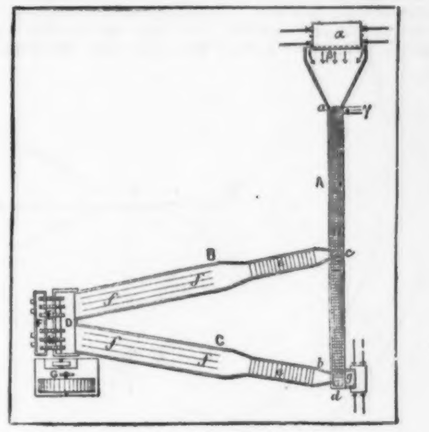


FIG. 2.—PLAN OF THE SLUICES.

The yield in gold of the sand found in each well was determined, and there was thus detected, throughout a length of 2,500 yards, the presence of a bed of alluvion from 30 to 60 inches in thickness, containing on an average 15 grains of gold to the ton. The deposit is of some breadth, but it is scarcely workable over a width of more than fifty yards. Over this extent only, the thickness of the barren soil that covers it does not exceed eight feet. The portion of the auriferous sand that can therefore be utilized in this valley contains nearly 660 pounds of gold.

This examination having been made, a canal was dug on the right bank of the stream and all the water was turned into it. Then it became possible to begin the exploitation properly so called.

The work is performed by three gangs of men. The first removes the mud and peat that covers the bottom of the stream. The second removes a stratum of blue clay 3 feet in thickness, situated directly over the alluvion, and carries it in small one-horse carts to the banks of the stream. The third gang digs up the auriferous sand and puts it into Decauville carts drawn by horses. The work always proceeds in the direction of up stream.

The contents of the carts are put into large 8 ton cars, which serve for the carriage of the material to the sluice, which is situated at a distance of one mile and a quarter on the banks of the Volschanka. The traction is effected by small locomotives running on a 3 foot track. In 1888, the exploitation occupied 300 laborers and 55 horses.

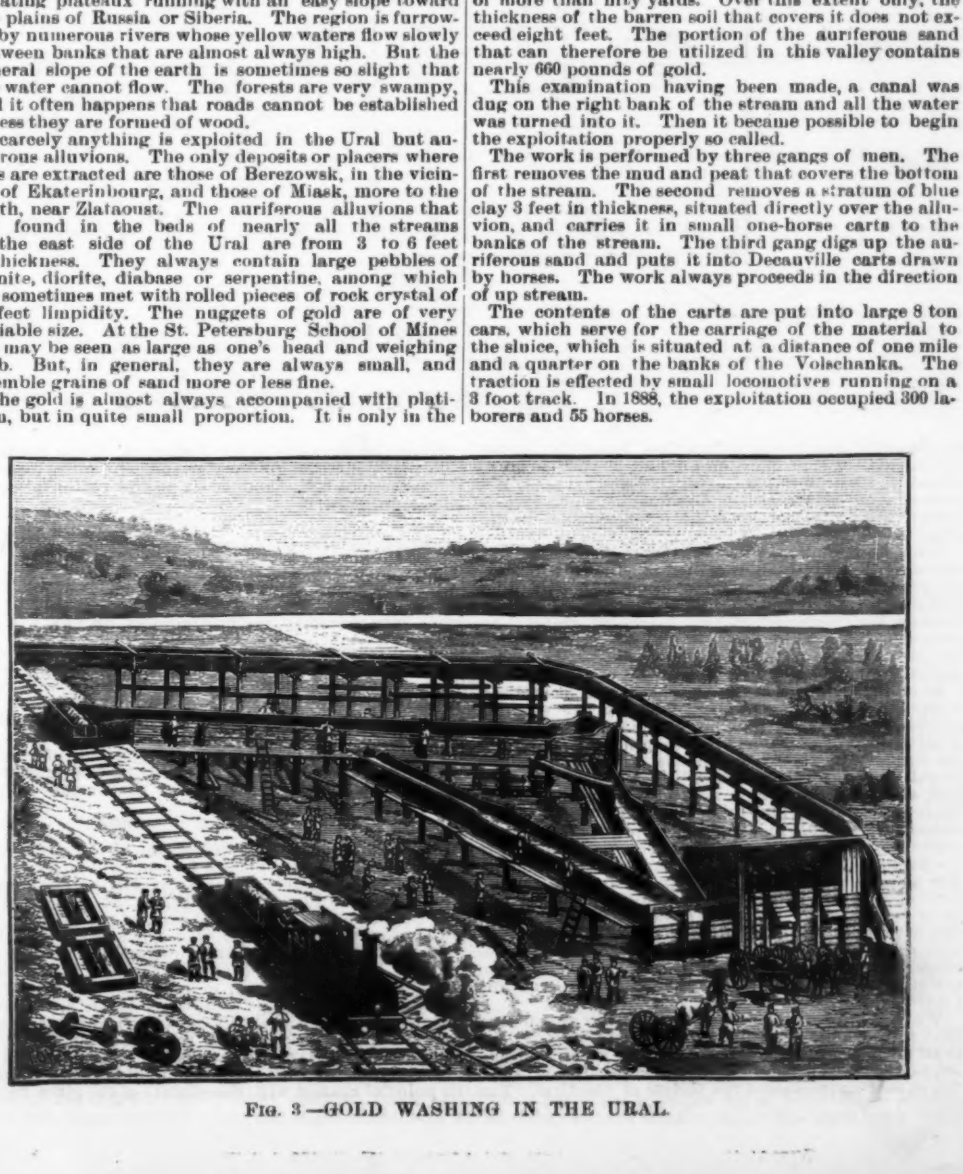


FIG. 3.—GOLD WASHING IN THE URAL.

The Bogoslowsk installations serving for the washing of the auriferous alluvion are peculiarly interesting. They are nearly the only ones of the whole of the Ural in which have been applied the American methods that permit of treating a large quantity of material in a short time and almost without manual labor. Such a result can be reached only when there is a large quantity of water available. So these methods are not applicable everywhere.

Fig. 3 gives a general view of the sluice. Fig. 2 will allow its arrangement to be better understood. It consists essentially of a large wooden trough, A, 60 ft. in length and 2½ in width, and with a descent of 7 feet in 100. The bottom of this trough is furnished, from *a* to *b*, with a sort of cast iron grille providing a series of spaces into which the particles of gold fall. At *c* and *d* there are two iron gratings that allow the water and fine sand to pass to the two lateral troughs, B and C. The large pebbles are arrested by the gratings and fall into a hopper, *g*, that delivers them to cars beneath. The sluices, B and C, are provided at the top, *e*, with a series of transverse wooden cleats, and at the lower part, *f*, with cloth having a long nap to arrest the finest particles of gold. This is a process employed from antiquity, and the "golden fleece" is a proof of it. The fine, washed sand falls into the basin, D, and is carried by the wheels and buckets, E, to the hoppers, F. The bucket wheels are actuated by a water wheel, G. The cars full of sand stop at *a*, and are emptied upon the upper part of the sluice, A. The water, which enters in great quantity, both through the orifices, B, and the conduit, *y*, carries along the entire mass with rapidity. The large stones stopped at *g* are taken out and thrown into the bed of the Volschanka. The same is done with the fine sand which has passed through the side sluices, B and C. As for the particles of gold, they, on account of their density, almost all stop in the interstices of the grille in the bottom of the sluice, A. The finest particles alone reach B and C. So the proportion of gold collected in the latter is always quite small.

The treatment of an 8-ton car load takes from 4 to 5 minutes. Each train is composed of four cars, but, as the production of the exploited localities is still relatively small, an interval of 15 or 20 minutes elapses between the treatment of two successive trains. At present from 530 to 550 tons of sand are being washed per day of ten hours. This quantity might be easily doubled.

At nightfall all the material that has been arrested in the interstices of the grille, and by the cloth, is gathered and washed upon large inclined tables under a feeble current of water, so as to gradually separate the lightest portions. Mercury is added to the mass in order to more easily unite all the particles of gold, and, after about an hour's work, there remains of the 550 tons treated during the day only a block, as large as one's fist, of gold amalgam and a pinch of grains of platinum which easily separates from it. To isolate the pure gold it is only necessary to distill the amalgam. The metal obtained contains, on an average, 90 per cent. of gold and 10 per cent. of copper or silver. The force employed at this installation is small: 20 men suffice to do everything. Finally, the results obtained appear to be very good. According to the analyses made at Bogoslowsk, sand that before treatment contained 15 grains per ton contains after the same but 1 8-10 grains.

We have already mentioned some of the advantages that these sluices present. There is another one that must not be forgotten. Almost all is of wood, and consequently the construction of the apparatus is one of the easiest matters amid the forests of the Ural. The only drawback to be noticed is the large quantity of water necessary for the treatment. In washing 500 tons of sand, 792,570 gallons of water are consumed.

Such installations require a large capital and can be established only at points where a sufficient quantity of gold can be found. In all the little streams of the region, where the alluvions exist in small quantity only, the establishment of them cannot be thought of. The administration of the district of Bogoslowsk authorizes the peasants to exploit these alluvions for themselves on the sole condition that they shall sell all the gold they collect to the bank. They are paid little for it, but it does not cost much to live there, and, moreover, the trade in gold is not free. Every robber or every receiver of stolen gold has the prospect of finishing his days in Siberia. The state alone has the right to acquire this material, and though it yearly gathers in very large quantities, gold coin is absolutely unknown in Russia. It is only at Paris that we find 5 ruble gold pieces.

The installations of these peasants are of the simplest character. They copy on a small scale the large sluices that they see, and, despite a very imperfect equipment, obtain a very good yield. Their business is a very hard one, and very uncertain, and yet the greed of gain makes them come from afar. Although they sometimes chance to gain much, yet they are almost always in deep misery. All that a Russian laborer receives above what is necessary to live upon is always used for the purchase of brandy. These searchers for gold are found everywhere. In the basin of the Volschanka alone they work over an extent of 36 miles. Upon the whole, it is these laborers distributed throughout the country that extract the greatest quantity of gold.

While the alluvions of the Tschernoia Rieva produce about 220 pounds of gold per annum, the entire district annually ships 800 pounds of it to the Ekaterinbourg mint.—*La Nature.*

RADII OF CURVATURE GEOMETRICALLY DETERMINED.

By Prof. C. W. MACCORD, Sc.D.

XIII.—THE SINUSOID, OR PROJECTION OF THE HELIX.

THE argument in the following paper is derived from the action of the instrument for tracing the sinusoid by continuous motion, described in the SCIENTIFIC AMERICAN SUPPLEMENT, No. 703. By reference to that description it will be seen that while the mechanism is in action, we can at any instant ascertain the simultaneous motions of two points, one of which traces the curve, while the other lies on the tangent to the curve at the point occupied at that instant by the first.

A New Method of Procedure.

The manner in which a knowledge of the motions of these two points at the same instant will enable us to determine the radius of curvature will be easily seen by the aid of Fig. 44, where P A is the tangent, and P C the normal to the curve shown, at the point P. If we suppose this point P to trace the curve, its motion at the instant must be in the direction of the tangent, and can have no side component; let P F represent its velocity. Suppose A B to represent the motion of the point A at the same instant; this has a side component A D, and A P D represents the angular velocity with which the tangent is rotating about P. Since the normal is always perpendicular to the tangent, it must be rotating with the same angular velocity about its point of contact with the evolute of the given curve; and P F perpendicular to P C is the actual linear motion of one point upon this normal. Therefore, drawing through F a perpendicular to P D, it will cut the normal in C, the center of curvature sought.

Now, regarding the sinusoid V P W, in Fig. 45, as the projection of the helix formed by rolling the inclined line W Y T around the cylinder shown; W T lying in the plane tangent to the cylinder, as shown at W' T' in the end view, Fig. 46, is tangent to the curve at W. During the rolling of this plane to the left, the extremity T' of this line must trace the involute T' U' in the plane T U S perpendicular to the axis of the cylinder. When it has rolled one-fourth of the way round, the plane, being always perpendicular to the radius, will have the position V' U', whence V U is the tangent to the sinusoid at the vertex V. To draw the tangent at any other point, as P, we have merely to determine the tangent to the helix at that point; the other projection of P is P', therefore P' L' tangent to the base of the cylinder is one projection, and P L is the other, which is the required tangent to the sinusoid; and by drawing normals at various points of W P V, the evolute R O N is readily mapped out.

In applying the new process explained at the beginning of this article to this curve, we may operate as follows:

Let it be required to find the radius of curvature at the vertex V; assign any velocity U' A' to the extremity of the tangent to the helix, then the corresponding motion of the point U in the tangent to the sinusoid will be U A; therefore A V U represents the angular velocity of the tangent V U about V. But V itself is moving to the left, with a velocity which may be ascertained thus: The helix is generated by a point which, while moving uniformly round the quadrant V' W', also moves uniformly parallel to the axis of the cylinder through the distance Z W, and the quadrant *m n*, in Fig. 46, is equal to Z W; by the principle explained in connection with Fig. 44, V' C must be rotating around C, the center of the circle, in Fig. 46, with an angular velocity equal to A' V' U'; therefore drawing through C a perpendicular to A' V', and producing it to cut at *a'* the tangent to *m n* at *m*, we have *m a'*, to which V *a*, in Fig. 46, is made equal, giving the required motion of V in the sinusoid. Then drawing through *a* a perpendicular to A V, it cuts the normal at V in R, the required center of curvature.

To find the radius of curvature at P, we have P L as the tangent, and P' L' the other projection of the tangent to the helix. Let L' G perpendicular to L' P' be the motion of L'. This is resolved into the horizontal and vertical components L' D, L' J'; and recollecting that L' P' here corresponds to the rolling rack in the mechanical device previously referred to, it will be seen that L J equal to L' J', the vertical component, is the actual motion of the point L in the tangent to the sinusoid. This motion has a side component L I, which determines I P L, the angular velocity of the tangent about P. The motion of P in its sinusoidal path may be determined directly thus: G P' L' is the angular velocity of the tangent to the helix about P', and drawing through C a perpendicular to G P', cutting L' P' produced in F, we have P' F' for one projection, and P F for the other, of the linear motion of P in the *helical* path; and just as V P W in that projection of the helix is the sinusoid, so the projection P F of the helical motion is the actual motion of P in the sinusoidal path. And then a perpendicular to L P, drawn through F, cuts the normal at P, in the point O, giving P O for the required radius of curvature.

Otherwise, by a more rigid adherence to the consideration of the mechanical movement alluded to, we should resolve P' F' (regarded as the velocity of P'

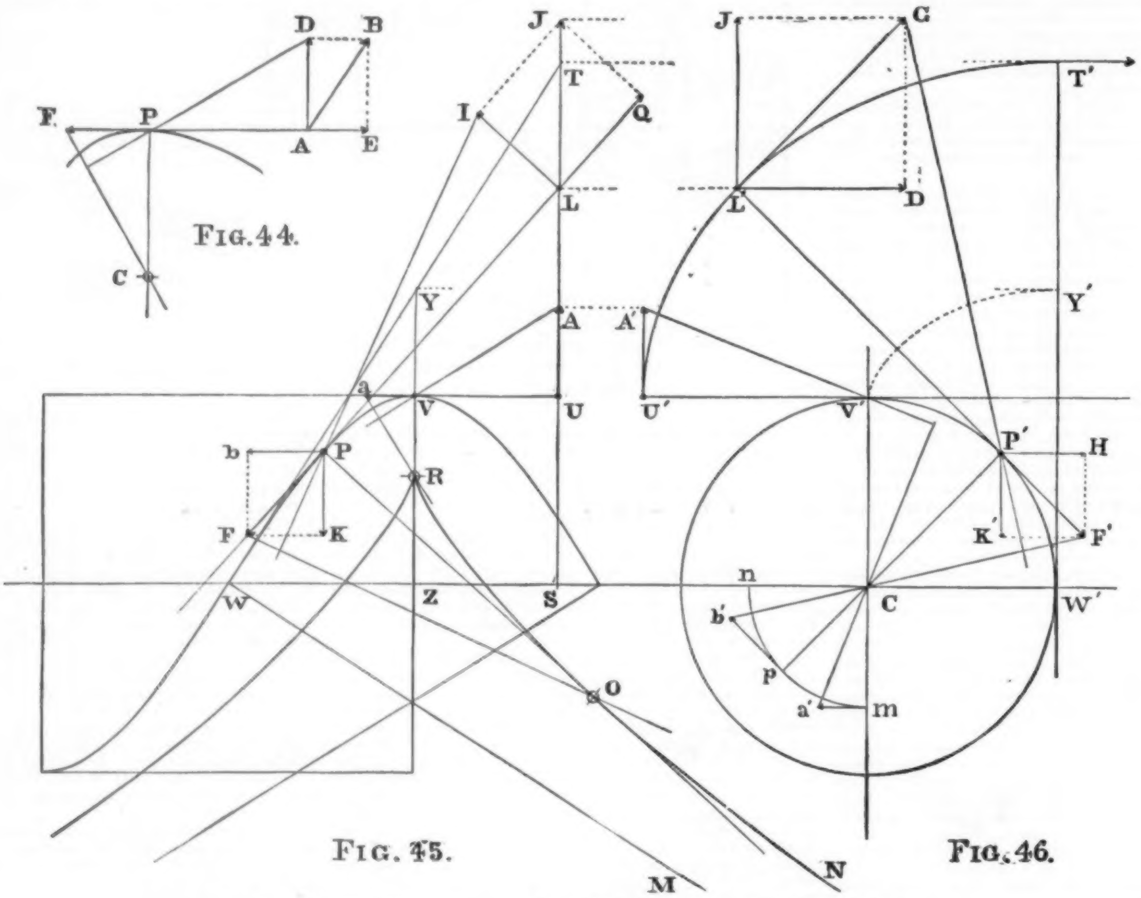


FIG. 44. FIG. 45. FIG. 46.

THE SINUSOID, OR PROJECTION OF THE HELIX.

about C in the plane of the paper into its components P′ H and P′ K′, to the latter of which P K, the transverse movement of P in the same plane, is equal. The longitudinal movement P b is equal to p b' in Fig. 46, where p is the point in which the radius P′ C, produced, cuts the quadrant m n, and b' is the extremity of the tangent to that quadrant at p, limited by the prolongation of F′ C perpendicular to G P′. Then by compounding P K and P b we find the resultant motion P F.

In the same manner the tangent W T is seen in Fig. 46 as W′ T′; let this move to the right, T′ having the direction of the arrow, which is horizontal, and has no vertical component. Then T, in Fig. 45, has at the instant no motion, but W is traveling in the direction of the curve, that is to say, of the tangent T W; consequently the normal is rotating about a center infinitely remote, or, in other words, has a motion of translation; and we thus see that W M perpendicular to T W is an asymptote to the evolute R O N, and the radius of curvature at W is infinite, as it should be, in accordance with the well known fact that the intersection of the sinusoid with its axis is a point of contrary flexure.

A SIMPLE CHUCK AND MICROMETER STOP FOR AMATEURS.

IN a former article a dividing machine for amateurs was described, and it is now purposed to describe a simple chuck for use with the same, and the micrometer stop that is used to regulate the depth of cut in the graduation of circles, etc.

Every one knows the difficulty in holding thin plates in a scroll chuck. They can be held by first backing them with something else; but wood is unreliable, metal expensive and hard to use; so a chuck which obviates all trouble, and once made will last always, is a desideratum. Such a chuck is the one described.

A face plate casting of the size required is obtained and then turned up and accurately fitted to the lathe. Its face is turned smooth and semi-polished, and its edge turned with a shallow groove, as shown in the first section in Fig. 1, which shows a side view of the chuck complete.

A ring is now turned up, the same size as the face plate, and its back face is turned with a projecting lip that fits accurately in the groove in the edge of face plate. This back face can be turned up first, and be fitted to the face plate before the front face and edges are finished to size.

The ring is now put in place and accurately laid off with a number of points to be drilled for screws. Two, four or better yet, six holes may be laid off. As stated, they should be *accurately* spaced, so that the ring may fit, haphazard, after once being removed, and not necessitate replacing exactly the same each time it is replaced.

The holes through the ring are clear. Those in the plate to match are tapped for a good strong machine screw—say a 10-24 size.

The ring can now be turned up on its edges and finished, and the chuck is complete.

Its use is obvious. Any flat, thin plate of a circular form can be clamped firmly and truly to the plate by the ring and screws, and the plate will be firmly supported against the tool, no matter how thin the plate may be.

Of course the chuck ring must be large enough to take in the size circle to be cut out, with room for the tool to work while cutting out the circle, after the other work has been done.

This chuck is so simple and easily made that several sizes can well be afforded. The amateur has then a chuck to be depended upon that will not fail him, instead of depending upon a makeshift of wood that may let his work slip, or bend, and so spoil all the job perhaps just as it is about completed.

Fig. 1, side view. Fig. 2, plan or front view. The micrometer stop is shown in Figs. 3 to 9, Fig. 9 being the finished tool.

It is simply a modification of the principle of the micrometer caliper, and all who are familiar with the latter tool need no description of its construction or use. The following is, therefore, for those who are not so familiar.

A bar of steel is bent and forged to shape, as shown in Figs. 3, 4, 5, a slot being cut in the bottom piece, as shown in Fig. 4, and a hole drilled and tapped at the upper end of the upright piece, as shown in Fig. 5.

To this latter hole is fitted a piece of steel that is drilled and tapped with a 20 or 40 thread for part of its length, and then drilled completely through with a somewhat smaller drill, as shown in Fig. 6. The dotted lines show the size and depth of the holes. This forms the "barrel" of the tool.

A screw is now got out that fits this threaded part accurately, and to a good working fit. One end is turned off plain for a certain distance to fit into and project through the smaller and plain hole in the piece just made, Fig. 6. The other end is also turned down plain for a purpose to be presently mentioned. See Fig. 8

Fig. 7 shows the size and shape of the hub piece—the sleeve—with its milled head. It is drilled so as to slip over the piece, Fig. 6, at a good working fit. It is best to turn it up out of the solid, and the bore should be accurately drilled and polished. Concentric with this bore, and through the head, a smaller hole is drilled that will just take in the short blank end of the screw, Fig. 8, at a tight driving fit. This hole should be slightly countersunk on the *outside*. The head may be milled or knurled with any pattern to permit a good grip to be taken.

The screw, Fig. 8, is now fitted to the sleeve, Fig. 7, by forcing the blank end into the hole and riveting down and finishing off. The piece, Fig. 6, is securely fastened into its place, and the tool is ready to go together.

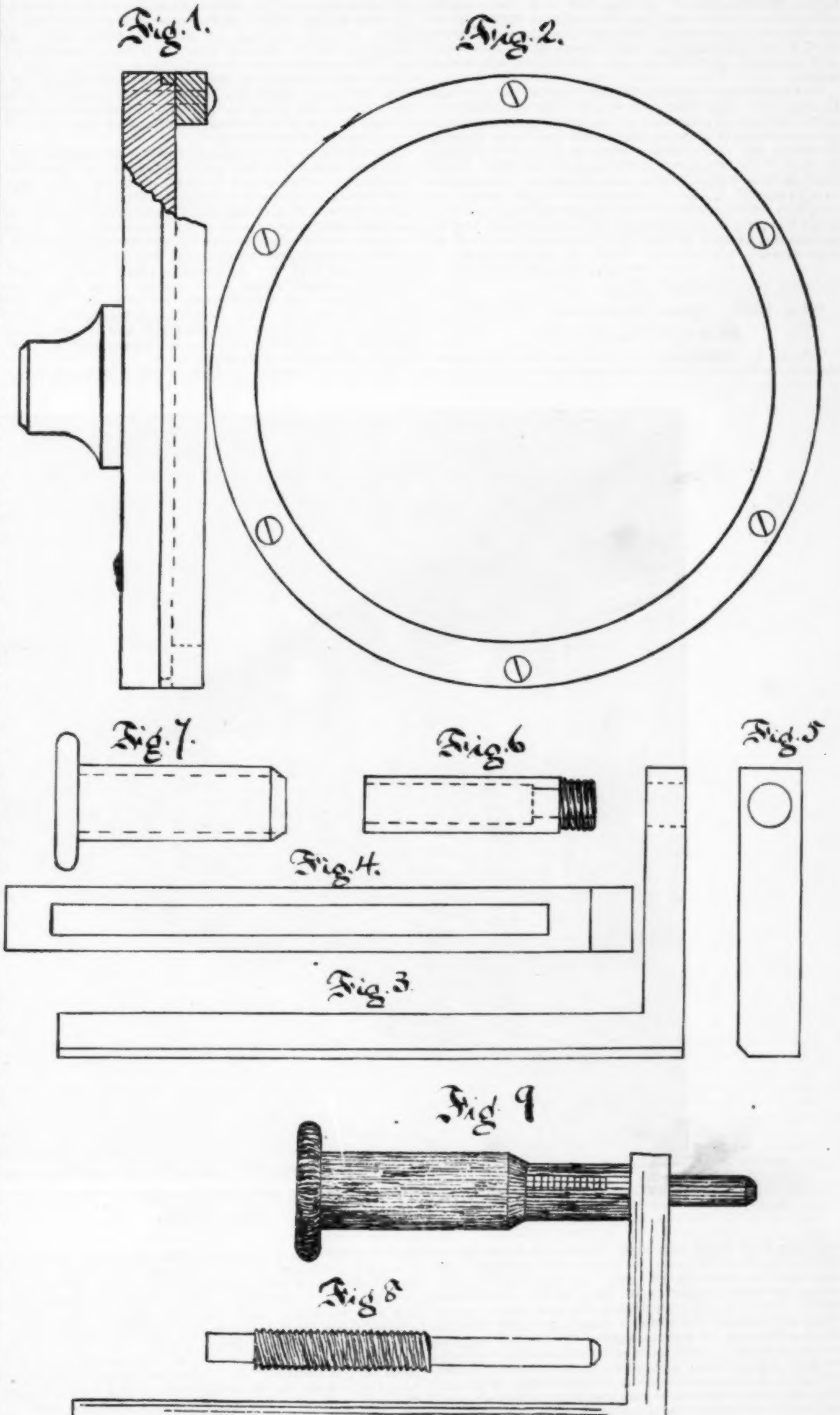
But before final putting together the parts should be graduated.

The graduation will depend upon the pitch of the screw and the fineness that is desired. If the screw has twenty threads, then, to get thousandths of an inch, fifty divisions will have to be put on the beveled end of the sleeve; as many more or less can be put on as may be desired.

This graduation can easily be done in the lathe by the use of an index plate or the dividing machine. An index plate works the faster of the two. A tool with a horizontal cutting edge should be used to cut the marks.

A reference line is now needed to which to refer these divisions. This line is cut upon the part shown in Fig. 6, at any convenient place, as shown in Fig. 9. It can be easily done in the lathe by locking the work between centers and moving a horizontal edged tool along the same by means of the slide rest.

For use as a micrometer stop this is all that is required, as the graduation upon the sleeve and the reference line are all that are required to adjust the stop to permit any depth of cut of the tool. But it



A SIMPLE CHUCK AND MICROMETER STOP FOR AMATEURS.

may also be desired to graduate the barrel, Fig. 6, as shown in Fig. 9. This can also be done in the lathe as follows: Set the screw-cutting gear to cut a 20 or 40 thread screw, according to which has been cut upon the screw of the micrometer. Place a vertical chisel-edged tool in the tool post, and arrange everything as though about to cut a screw thread upon the piece, Fig. 6, the reference line having first been cut. Turn the lathe over slowly, *with the tool drawn back*, so as not to touch the work until the reference line comes in sight, then advance the tool so as to bear lightly—it is well to adjust a stop to regulate the depth of cut—and let the tool bear for a short distance, draw back the tool, make another turn and another cut, and so on, a cut for each revolution. Those cuts will be the elements of a screw thread, to be sure, but they will be so near right lines perpendicular to the reference mark as not to appear inclined, and will answer all the purposes.

The slot in the base of the tool is to permit of its being fastened to the lathe bed. Screw holes may be tapped at regular intervals along the bed, and by these the tool can be screwed down and adjusted, as readily explains itself.

Besides its use with the dividing machine, this micrometer stop has many uses in other work, and will well repay the amateur for the trouble of making it. By its use the length of a cut up to a shoulder upon screws, shafting, and any such work may be regulated to a nicety, and, while duplicates are being made, dependence can be placed upon it to bring them out alike in length.

While upon this point of micrometers, I would like to call attention of amateurs to the ease with which any of these apparatus for lathe work, and their lathes also, can be graduated so as to make all screws to be micrometers.

In making new work, either light or heavy, all one has to do, to get a graduation of hundredths or thousandths, is to cut the screws for the work with 10ths,

20ths, or 40ths of an inch. A heavy screw can be 10 threads to the inch, as well as some odd number. Then a graduation upon the head of the screw, or upon a sleeve fitted under the handle, of ten parts readily gives hundredths of an inch. The tail screw and cross feed screw of my lathe are so graduated, and I can drill to the hundredth of an inch by the graduation upon the tail screw, or take a chip of one two-hundredth inch on turning by the graduation upon the cross feed screw.

If one prefers to work by eighths, sixteenths, etc., then the screws need only to be cut with eight, sixteen, or thirty-two threads to the inch and the circular graduation be halves, quarters, eighths, etc., to get down as fine as one wishes to go. I have a slide nut that runs by the thousandths of an inch, the tool post runs in and out by the thousandths also, a gear cutter that I can set by thousandths, and any one can make these tools in a similar manner, and thereby save lots of time and patience, and at the same time turn out better work.

The amateur will find in the end that it pays to take time and do only first class work. He generally has plenty of time to put upon a job, and if he were not in quite so much of a hurry, and would not be so desirous of seeing the result of his work, and "how it is going to work," he would produce more jobs that would bear critical inspection, and be in reality first class in every respect. Adopt the motto that "nothing but the best will do," instead of "anything will do," and in a short time the work will begin to tell for itself, and its possession, as well as the "fun of making it," will be a pleasure.

C. D. Parkhurst,
Lieut. Fourth Artillery.

THE NEW YORK TELEPHONE SERVICE.

By Herbert Laws Webb.

There are comparatively few people who appreciate the vastness of the telephone system in a great city like New York, and still fewer that have the opportunity of seeing from the inside the enormous difficulties to be overcome by telephone engineers in order that the service may reach that point of efficiency which they are always striving for and which impatient subscribers declare—in language more forcible than polite—to be unattainable. There are carping critics, generally newspaper scribes in want of a better subject upon which to expend their power of invective, or individuals belonging to that class of present day offenders against our peace and happiness who *will* write letters to their favorite daily organs on matters about which they are profoundly ignorant, who maintain from time to time that the telephone companies persist in rubbing along with antiquated apparatus, rusty and badly constructed lines and a general state of cheap disorganization, so that, secure from competition as they are, they may continue to extract from the poor, down-trodden subscriber the maximum *quid* in the way of rates in return for the minimum *quo* in the shape of service. That such a state of affairs does not exist, and, in the more important companies, never has existed, goes without saying, but even many of our readers who keep themselves well informed on telephone matters will learn with surprise of the high pitch to which the methods, and what may be termed the technical policy, of the Metropolitan Telephone and Telegraph Company have been brought, and how wide a difference exists between the actual state of matters telephonic in New York and the lugubrious descriptions of them doled out to readers of the daily press. During the past few years the enormous plant of the Metropolitan company has undergone, and, in fact, is still undergoing, a gradual and complete reorganization, and it is not too much to say that in the system of equipment for the new buildings now elaborated, the very acme of perfection in modern telephone working has been reached.

Beginning with the Cortlandt street exchange, situated at No. 18 Cortlandt street, familiarly known as "Telephone Headquarters," we find a Western electric multiple switchboard with capacity for 6,000 metallic circuit subscribers; this board occupies the entire floor of the eighth story of the building, and has assimilated the subscribers formerly connected to the old exchanges at John, Pearl, Nassau, and New streets. The engraving, Fig. 1, shows one side of this board. Quite recently another of the old down town exchanges, that at Murray street, has been abandoned and its subscribers transferred to Cortlandt street and to the present exchange at Spring street and Broadway. This exchange again will be shortly be installed, with an entirely new plant, in a model telephone building erected by the Metropolitan Company at the corner of Spring and Wooster streets.

The Cortlandt street board, which is the largest multiple switchboard in the world, has been in operation for about two years, and is now operating more than 3,800 subscribers, many of them equipped with metallic circuit lines. The average daily number of connections between subscribers made on this board is 48,236, and the average for the whole city is 103,621, about 98 per cent. of these connections being made between the hours of 8 A. M. and 6 P. M. At present there are 128 operators at Cortlandt street, each one of whom attends to between four and five hundred subscribers' calls per day of ten hours. The switchboard has given excellent service since first put into use, and a few minor changes shortly to be made in its equipment will still further increase its efficiency.

The most interesting part of the Cortlandt street building for many readers of *The Electrical Engineer* is where comparatively few visitors penetrate; below the ground floor is a department known as the "underground room," where the cables which find a deviating and tortuous path through New York's much abused subways terminate and make connection with the switchboard eight floors above. The room in its present state is not calculated to impress the technical man very favorably. As originally planned, the cable terminals were to be connected to the switchboard through a distributing board which lines the walls of the operating room at the rear of the switchboard. This distributing board consists of a series of vertical wooden racks placed at convenient distances apart to facilitate the handling of wires; above the racks are arranged the lightning arresters and resistance coils. The underground cables are extended from the cellar by flexible rubber-covered cables running in ducts the height of the building and connected to one side of the lightning arresters and resistance coils. The distribution is then effected by running wires through the racks from the lightning arresters to the part of the switchboard required, the connection to the wiring of the board itself being reached by running the wires through troughs under the floor and up at the back of the board.

The underground system, however, has grown at such an extraordinary rapid rate that this method of effecting the "cross-connecting," a very important part of the daily work of a large telephone exchange, has outgrown its usefulness, so much so that much of the cross-connecting work necessitated by cutting new underground cables into service, changes in subscribers' addresses, etc., has had to be done in the underground room.

The problem of reducing cross-connecting to a systematic process devoid of all risk of confusion or literal "cross-connections" involving trouble and annoyance to all parties concerned has lately been attacked in earnest, and the investigations conducted by telephone engineers has led to the invention and development of the Hibbard distributing board, which is illustrated in perspective view in the accompanying engraving, Fig. 2, which represents the one to be placed in the underground room at the Cortlandt Street Exchange. Mr. Hibbard has solved in a very simple manner the difficulties of "cross-connecting," and his distributing board is already in operation in several of the principal exchanges in the country, such as, for instance, those at Philadelphia, Boston, Baltimore, Albany, etc.

The engraving gives a general idea of the board. In telephone work the word "board" has got to be quite a conventional term, and in this case it stands for a framework built up of iron gas pipe and rods, of long and narrow dimensions, the vertical parts of the frame serving for supporting the hard rubber bases to which the connecting devices are attached, and the cross bars forming supports for the cross-connecting wires which run through the framework from side to side. It is plain that if at each side of the framework we have a number of hard rubber strips provided with small metal plates to which wires are permanently connected, it will be a perfectly simple matter to connect any two wires terminating at one side of the board to any two terminating at the other by merely running a pair of wires through the racks in the middle of the framework.

The arrangement of the underground room at Cortlandt street when the new distributing board is in place will be as follows:

Above the iron cable heads which form the terminals of the underground cables will be placed hard rubber strips provided with the proper number of Hibbard lightning arresters for each cable, and the cables will all be wired permanently to these arresters, all connections being soldered. From the arresters to the connection strips on the distributing board short cables will be run, thus extending the underground cables direct to one side of the distributing board, the only intervening piece of apparatus being the lightning arresters; as a break can be made in the line at this point by the removal of the fusible coil, it is an easy matter to test any line in either direction when hunting for "trouble" on a subscriber's wire. In the same way cables will be run from the switchboard to the strips at the other side of the distributing board; these cables will be soldered direct to the switchboard terminals in the operating room, and also to the metal ears on the hard rubber strips of the distributing board, the wires belonging to the different drops being arranged in proper order, drop number one being the first connection on the first trip.

This arrangement practically means the transfer of the switchboard terminals to the terminals on one side of the distributing board. We now have the terminals of the underground cables and those of the switchboard brought face to face, or, rather, back to back, separated merely by the iron framework, and in order to connect any desired pair of wires in any underground cable to a drop in any part of the switchboard, the only operation necessary is to run a pair of wires

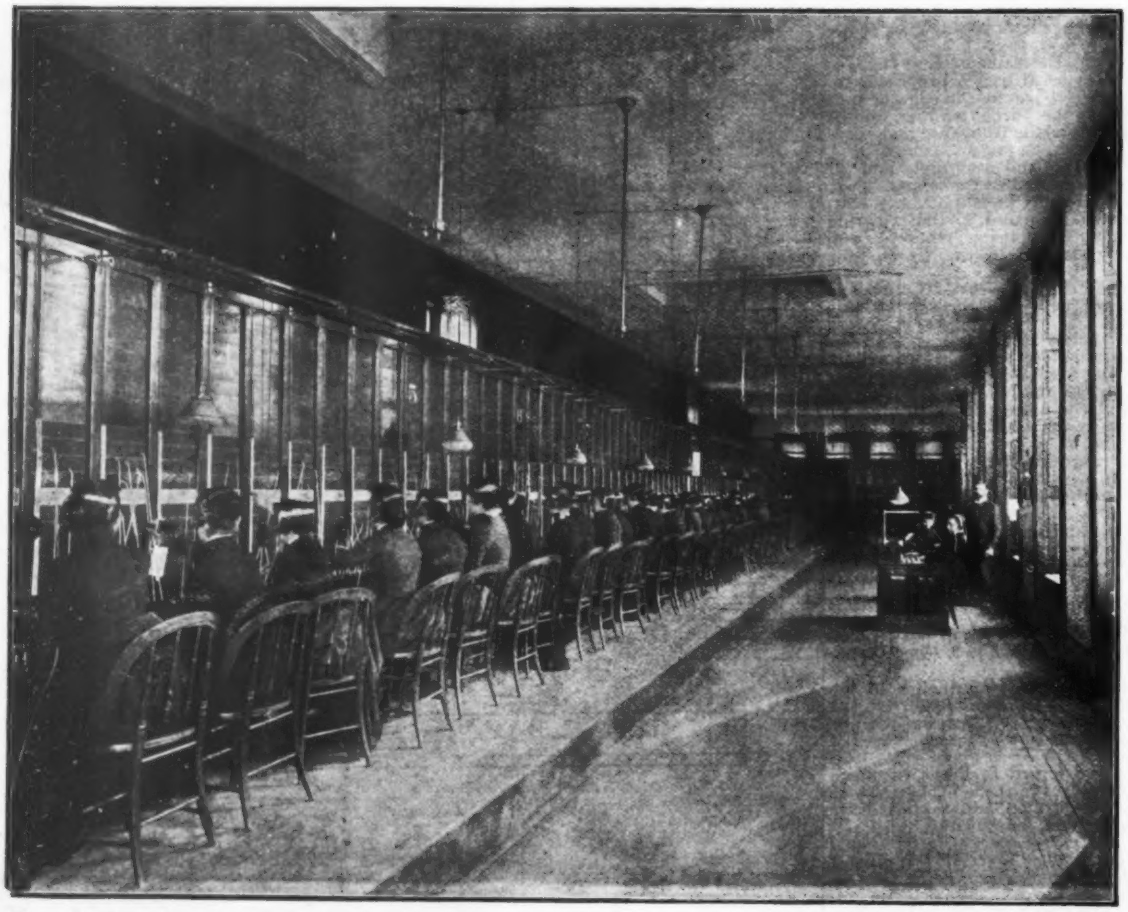


Fig. 1.—ONE SIDE OF THE NEW MULTIPLE SWITCHBOARD AT THE CORTLANDT STREET EXCHANGE, NEW YORK.

through the rack, making the requisite connections at each end. This will be the only cross-connection between a subscriber's line and the drop required at any part of the exchange, and it will easily be recognized that this method of doing the work simplifies matters to a very great extent, and renders it possible to make any number of changes between lines and their drops with the minimum expenditure of time and labor and the maximum amount of certainty.

The board designed for Cortlandt street will be 38 ft. long, 7 ft. high, and 3 ft. 1 in. wide, and will have thirteen separate planes on which the cross-connecting wires will be run. All the cross-connecting wires will be rubber-covered and twisted in pairs. The board has capacity for 154 underground cables, or, say, 7,700 pairs of wires. The cross-connecting wires will never be run diagonally through the framework, but when a connection has to be made between a point high up on one side of the board and another low down on the other, the connecting rod will be run horizontally on the plane coinciding with its starting point and then up or down when opposite its destination in a vertical division of the framework at the rear of the board; in this way the openings at the front of the board will never be obstructed by the cross-connecting wires, the maximum number of which in any one plane will be about 600 pairs.

The work of putting in the distributing board is to be commenced very shortly, and from the description already given a faint idea may be formed of the magnitude of the task, involving the entire reorganization of all the connections between the underground cables and the switchboard and the making of some tens of thousands of new connections.

The underground plant of the Metropolitan Company has had a marvelously rapid growth since the inception of the underground wire regulations in New York. At present there are in actual operation from the different exchanges nearly 300 separate underground cables, each containing 50 twisted pairs of conductors, aggregating 145 5 miles of cable, or 14,553 miles of wire. The Cortlandt Street Exchange, of course, has the greatest number of cables, as no less than 140 of the 300 terminate at this office. The cables vary greatly in length, as some are only a few hundred feet long, running to buildings in or near Cortlandt street, where they terminate on roofs and are extended to subscribers' offices by overhead wires. There are many cables over a mile in length, the longest being one of two terminating on a pole at Fifty-ninth street and Tenth avenue, which measures 29,069 feet, or nearly six miles.

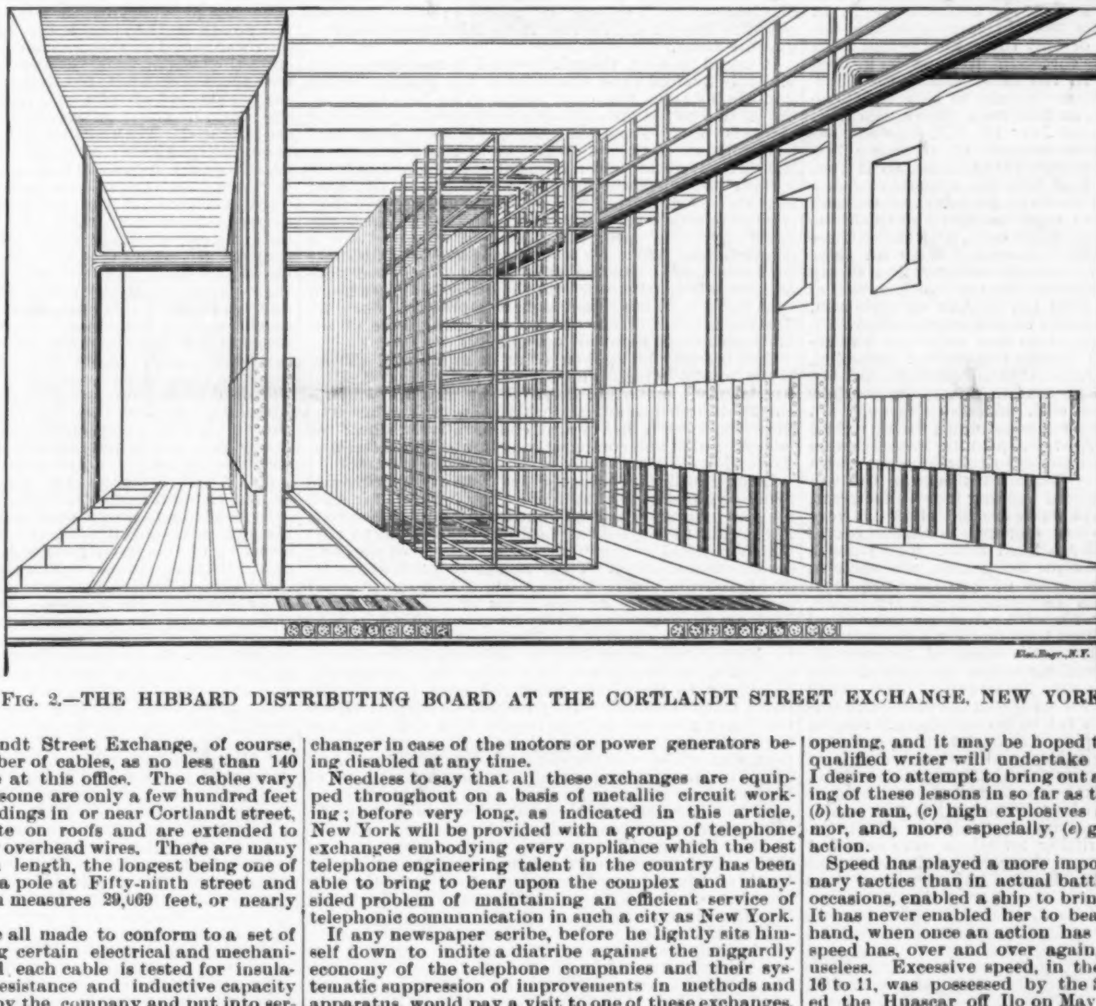


FIG. 2.—THE HIBBARD DISTRIBUTING BOARD AT THE CORTLANDT STREET EXCHANGE, NEW YORK.

The cables used are all made to conform to a set of specifications exacting certain electrical and mechanical requirements, and each cable is tested for insulation and conductor resistance and inductive capacity before it is accepted by the company and put into service. Full records are kept of all these tests, so that the life of every cable can be watched from the time it is first laid down. At Cortlandt street a testing room has been fitted up containing a complete set of fine testing instruments, leads being run to the underground room where connection is made with the cable heads.

At Spring street, Eighteenth street, Thirty-eighth street and Seventy-ninth street nearly all the subscribers' lines enter the exchanges through underground cables, and the rapidity with which the underground work has been pushed has necessitated an equally rapid and radical change in the equipment of the company's central offices. The Cortlandt Street Exchange is a modern telephone building, but changes there, as we have seen, have become necessary long before the building has lost its modern air. With the other exchanges the company has adopted the very sweeping policy of entirely abandoning the old plant and removing the subscribers' wires to entirely new buildings erected by the company and equipped throughout as model telephone buildings, according to the most approved principles of telephone engineering, as that branch of the science is understood to-day.

One of these buildings has just been inaugurated at West 38th street, the lines formerly running to the old exchange, at 39th street and Sixth avenue, having all been transferred to the new offices less than two months ago. A similar building has been erected at the corner of Spring and Wooster streets, and the transfer of the old Spring street exchange to the new will be made by the beginning of next year. Another telephone building is to be located on Franklin street, and still another at Broad street. These four new offices will have an aggregate capacity for operating 14,400 metallic circuit lines. Uptown, a new office will shortly be established at 79th street and Third avenue, and the Harlem exchange is being rehabilitated in order to arrange the apparatus for metallic circuit working; to place the Harlem exchange in connection with the underground system a subway is now being built in that direction, the route of which for a considerable distance passes through solid rock which has to be blasted out in order to provide a passage for the subway.

The equipment of the new telephone buildings will not differ materially from that of the Cortlandt street office, with the exception that all the vital parts of the office will be on the same floor. Instead of terminating the underground cables in the cellar, they will be run up a shaft to the top floor, where a "terminal room" will be provided for their reception. The Hibbard distributing board will be located in this room and the cross-connecting will be done as already described. In the terminal room there will also be a chief inspector's desk provided with spring jacks and connections, by means of which the chief inspector can plug on to any faulty line a set of testing instruments consisting of Wheatstone bridge, galvanometer, relay, etc., and so determine the nature and approximate locality of the trouble. This chief inspector will have charge of all the "trouble men" attached to his exchange, and will keep full records of all incidents connected with the maintenance of the lines. In all exchanges, current for ringing up subscribers is supplied by small power generators run by electric motors; these are located in a separate department called the power room, which also contains a large battery of gravity cells to be used in connection with a pole changer in case of the motors or power generators being disabled at any time.

Needless to say that all these exchanges are equipped throughout on a basis of metallic circuit working; before very long, as indicated in this article, New York will be provided with a group of telephone exchanges embodying every appliance which the best telephone engineering talent in the country has been able to bring to bear upon the complex and many-sided problem of maintaining an efficient service of telephonic communication in such a city as New York.

If any newspaper scribe, before he lightly sits himself down to indite a diatribe against the niggardly economy of the telephone companies and their systematic suppression of improvements in methods and apparatus, would pay a visit to one of these exchanges, he would find both methods and apparatus of a far higher standard than in many other technical establishments. Then let him figure out the cost of an eight story telephone building, and a multiple switchboard for 3,600 subscribers, of the distributing board, motors, generators, and batteries, of the miles and miles of wire within the building and the miles of underground cable without, let him ponder over the cost of maintenance and the salaries of a staff which would fill a good sized theater, and if the calculation leaves him still with power to think, he will think twice before informing the public that the telephone companies spend no money, and merely plot day and night to achieve the difficult operation of catching whales with sprats.—*The Electrical Engineer.*

ALLOY OF ALUMINUM AND TIN.

M. BOURBOUZE has compounded a very useful alloy of aluminum and tin, by fusing together 100 parts of the former with 10 parts of the latter. This alloy is paler than aluminum, and has a specific gravity of 2·85, that is, it is a little heavier than the pure metal, but not too heavy to be formed into parts of instruments intended to be very light. The alloy is not so easily attacked by the several reagents as aluminum is, and it can also be worked more readily. Another great advantage of it is that it can be soldered as easily as bronze, without further preliminary preparations.

NAVAL WARFARE, 1860-1889, AND SOME OF ITS LESSONS.

By W. LAIRD CLOWES.

THE historical method has lately been used with instructive effect by Admiral Colomb and others in the discussion of certain of the larger problems in modern naval strategy. There are several vexed questions connected with the armament of modern ships of war, the solution of which may be equally assisted by an appeal to history. In the consideration of any general schemes of offensive and defensive naval strategy, the inquirer who is in search of precedents is obliged to travel back to the period of the long wars with France and to the age of Nelson and St. Vincent. There has since then been no naval strategy on a large scale. In the consideration, on the other hand, of the relative value and importance of different schemes of offensive and defensive armament for vessels of war, he has the advantage of commanding a store of much more recent precedents in the history of the numerous naval combats which have occurred since the more or less complete adoption of existing conditions. Steam, armor, the heavy gun, the ram, the torpedo, high explosives, the quick-firing gun, and the machine gun are not so new but that they have already been tested in more than one action. And to-day, when technical experts are endeavoring to determine what, in the future, will be the chief factor in naval warfare, many of the lessons of the civil conflict in America, of the war of 1866, of the struggle in Paraguay, of the Franco-German campaign, of the fight between the Shah and the Huascar, of the Russo-Turkish war, of the battles between Chili and Peru, of the bombardment of Alexandria, and of the French operations in Chinese waters are surely valuable and suggestive in the highest degree. Too little attention has hitherto been paid to most of these; perhaps because there is no good English work in which the naval operations of the last thirty years are accurately chronicled and criticised. For such a work there is, apparently, an excellent opening, and it may be hoped that ere long some well qualified writer will undertake it. In the meantime, I desire to attempt to bring out a few of the more striking of these lessons in so far as they concern, (*a*) speed, (*b*) the ram, (*c*) high explosives and torpedoes, (*d*) armor, and, more especially, (*e*) guns, and their *role* in action.

Speed has played a more important part in preliminary tactics than in actual battle. It has, on several occasions, enabled a ship to bring her enemy to action. It has never enabled her to beat him. On the other hand, when once an action has been begun, excessive speed has, over and over again, proved to be almost useless. Excessive speed, in the proportion of about 16 to 11, was possessed by the Shah when she engaged the Huascar off Ilo on May 29, 1877. But there is no reason for believing that the Shah could have ever effectually rammed her opponent, had she desired to do so.

Excessive speed, in the proportion of about 11 to 5, did not, at the battle off Iquiqui, on May 21, 1879, put the ironclads Huascar and Independencia on terms of overwhelming superiority with the small unarmored Chilian vessels Esmeralda and Covadonga. It is true that the Huascar rammed the Esmeralda and sank her, but not until the Esmeralda's engines had been rendered powerless. And when the 12 knot Independencia tried to ram the 5 knot Covadonga, the slower craft easily slipped away, leaving her enemy to run upon a rock. At the battle of Angamos, on October 8, 1879, the 12 knot ironclad Cochrane brought the slower Huascar to action, but repeatedly failed to ram her. But when the Huascar, after a most gallant defense against largely superior forces, at last hauled down her flag, the fearful damage which she had sustained was found to be due to gun fire, and to that alone.

Admiral Sir George Elliot was for many years the arch champion of the ram. But I think that it is demonstrable that the ram, unless the way for it be first prepared by means of effective gun fire, is an almost useless weapon. In the history of modern naval warfare there are on record one or two cases of successful and dozens of examples of fruitless attempts to ram. The earlier ones occurred during the civil war in

America. On March 8, 1862, the Virginia, late Merrimac, rammed the Federal ship Cumberland, and eventually sank her. But the Cumberland was at the time at anchor. Next day, when the Monitor appeared upon the scene under steam, the Virginia, on at least five separate occasions, tried in vain to ram her. A few weeks later, in April the Confederate ironclad Manassas attempted to ram a Federal vessel, but missed her, ran ashore, and had to be abandoned. On August 5 following, the Arkansas did effectually ram the Federal ship Essex, but not until the latter's machinery had been seriously damaged. And again, on August 5 1864, the Tennessee could not be rammed so long as her engines worked properly. These are the chief ramming incidents of the war of secession. Neither the Kearsarge nor the Alabama tried ramming during the course of their historical fight off Cherbourg. During the four years' struggle there were hundreds of attempts at ramming, but not more than a half a dozen of them were successful. The results were very similar in the war of 1866. It is on record that at the battle off Lissa on July 20, 1866, nearly every ship engaged—and there were over forty vessels—made one or more efforts at ramming, yet the only craft that suffered by the ram had just previously had her steering gear temporarily damaged by gun fire. But for this, the Ferdinand Max would scarcely have sunk the Re d'Italia. In the Paraguayan war, also, the only effective ramming was exercised by the Brazilian ship Amazonas upon a Paraguayan craft that was already disabled.

During the war of 1870-71 the efforts of the French gun-vessel Bouvet to ram the German gun-boat Meteor, off Havana, were futile. In the engagement off Carthagena between the Spaniards and the revolutionists on October 10, 1873, ramming was not attempted. In the course of the conflict between Chili and Peru the ram was very often used, as, indeed, it had been, without success, by the Huascar in her fight with the Shah in 1877. In the battle off Iquiqui, on May 21, 1879, the Huascar, as has already been mentioned, sank the gallant Esmeralda by ramming her. But only when the Esmeralda was unable to move. In two previous endeavors the Huascar—although her opponent had a speed of only three knots—had been unsuccessful, and in the successful attempt she injured herself considerably. In the same action, the Independencia tried three times in vain to ram the Covadonga, and ultimately, as has been shown, sacrificed herself. In the action of July 10, 1879, between the Peruvian Huascar, then capable of steaming 10½ knots, and the Chilian corvette Magellanes, an 11-knot ship, the former made four fruitless attempts to ram the latter. And at the battle of Angamos, on October 8 following, the Huascar tried to ram the Cochrane and the Blanco Encalada each once, and three times escaped the ram of the Cochrane. With all these examples in point, it is scarcely exaggeration to say that a ship, so long as she can keep way on her, and so long as she can steer, need not fear an enemy's ram, provided, of course, that she be properly handled.

The value of high explosives and torpedoes was repeatedly demonstrated during the war of secession, the Russo-Turkish war, the Chilian conflict, and the French operations in China. But the limits of their powers were also defined with tolerable clearness. In North America many vessels were blown up by mines or torpedoes. But torpedoes, speaking broadly, were almost as fatal to their users as to those against whom they were used. In the Russo-Turkish war, the torpedo undoubtedly exercised a strong moral effect, but, as compared with what was expected of it, did very little. A Russian gun-boat engaged in the attack of Sulina was blown up by a fixed mine. The Turkish monitor Seifi, a bad look-out being kept, was sunk in the Danube by the explosion of two spar torpedoes applied by Lieutenants Tschestakoff and Doubasoff, on the night of May 25, 1877. And an unarmored Turkish war ship of about 1,300 tons displacement was sunk in Batoum Roads on the night of January 25, 1878, by two Whitehead torpedoes discharged from boats under Lieutenant Zatzarevni. But other attempts—and there were many—to use mines and torpedoes of various kinds led to no satisfactory results, and it is tolerably apparent that, with care, ordinary material precautions, and a good look-out, a ship, if not actually in action with another ship or ships, should generally be able to protect herself against weapons of this class. In the Chilian conflict, again, the torpedo exercised a moral effect, but did little. On May 5, 1880, two drifting torpedoes were sent out of Callao harbor, but were detected by the Amazonas and rendered harmless. Several Lay torpedoes were employed, but, so far as is known, they did no damage, and although the ships Loa and Covadonga were successfully blown up by the Peruvians off Callao, the work was effected by strategy of a kind which, it may be hoped, will not often be repeated by civilized belligerents. The Loa was destroyed by a mine concealed in a fruit boat. The Covadonga was sunk by dynamite concealed in the keel of an empty gig that was sent adrift by the Peruvians and unsuspectingly picked up by the blockaders. Lieutenant Goni, of the torpedo boat Guacolda, tried to blow up the Peruvian cruiser Union with a spar torpedo, but only succeeded in demolishing part of the vessel's boom protection. Previously the Peruvians had endeavored, from the Huascar, to destroy the corvette Abtao with a Lay torpedo, but the weapon turned back on its course, and would have struck the Huascar, had not one of her lieutenants, Don Diez Conseco, gallantly jumped overboard in his clothes and guided the dangerous machine aside. No wonder that Admiral Grau, on his return to Iquiqui, declined to have anything further to do with such traitorous things, and buried the rest of his Lay torpedoes in the cemetery there. In China the French used torpedoes of other makes, and succeeded in disabling one vessel. But the two torpedo-boats which were employed—Nos. 45 and 46—were both put out of action by light gun-fire.

As regards armor protection for ships, the verdict of recent naval warfare seems to be as follows. It is difficult to over-rate the value of armor, provided the armor be thick enough to absolutely keep out heavy projectiles and especially shells. It is hard to overrate its danger when the armor is so weak as to permit projectiles either to pierce it or to shatter it by exploding deep in its substance. Speaking of the Huascar, at the battle of Angamos, where she was obliged to strike to the Chilians, Lieutenant Theodorus B. M. Mason, of the United Navy, says: "The armor in this case was only a great disadvantage to her. It served to explode the enemy's projectiles, which it in no case stopped when they struck at any but the smallest angles. The backing and inner skin only served to increase the number of fragments which were driven into the interior of the vessel with deadly effect. On the contrary, the shell that passed through the light iron sides of the forecastle did not explode, and did but little damage." The Huascar's side armor, it should be explained, was only from 2½ to 4½ in. thick, with 10 in. of teak backing, and an inner skin of ½-in. iron. The turret armor was 5½ in. thick, re-enforced round the ports with extra 2-in. plates, and backed with teak to make up a total thickness of 18½ in., the whole having behind it a ½-in. iron skin. The ship, when boarded by her captors, was a shambles. Steel or compound armor of 5 in. in thickness would probably keep 90 per cent. of all save the heaviest shells from bursting within a ship. But any thinner side armor—except for mere gun shields—would seem to be a dangerous snare, and for the protection of a vessel's vitals a considerably greater thickness is necessary. All recent naval engagements teach with singular unanimity that the ship's engines and boilers should be protected at all hazards. A modern ship that cannot move is, in action, doomed, no matter how powerful she may be.

From what has been written above, it is apparent that speed, the ram, and high explosives were factors of secondary importance in the majority of the naval actions of the last thirty years. The main factor was almost always gun-fire. On March 8, 1862, the Virginia vanquished the Congress entirely by gun-fire; next day the Monitor drove off the Virginia entirely by gun-fire; on April 7, 1863, the Federal ram Keokuk was sunk entirely by gun-fire; on June 17, 1863, the Weehawken sunk the Atlanta entirely by gun-fire; the Alabama was destroyed entirely by the gun-fire of the Kearsarge; the Huascar was vanquished and captured simply and solely by gun-fire; at Lissa, the Palestro was destroyed by gun-fire; in the Danube a Turkish monitor was sunk entirely by gun-fire; and nearly all that the French did in the River Min was effected by gun-fire alone.

It would be easy, though it would be monotonous, to multiply fivefold these examples of the position which gun-fire holds as the chief factor in modern naval actions. Up to the moment of actual fighting, the chief factor is speed. From that moment onward, at all save the shortest distances, it is gun-fire, and gun-fire to the end. If armor had no limitations, armor might, in certain circumstances, supplant gun-fire as the most important factor; but since it is confessedly impossible so to armor the whole of a ship that no projectile shall anywhere enter her, armor is, at best, only a compromise. We know that it cannot afford absolute protection. All that we hope is that it may occasionally stand in good stead. On the other hand, we know that the better, the fuller, and the more rapid our gun-fire, the greater is our chance of hitting some of the inevitable weak points of our enemy.

Gun-fire may be spoken of as of two kinds. There is the gun-fire which is chiefly designed to act against the enemy's material; there is the gun-fire which is chiefly designed to act against the enemy's men. The former species is heavy and comparatively slow; the latter is quick and comparatively light. The latter first demands consideration.

Light gun-fire includes the fire from quick-firing and machine guns, as well as from rifles; and its function may be characterized as murderous and preventive. Light guns to-day hold a position equivalent to that which was held by the "murthering pieces" of the early seventeenth century. Their aim is to prevent the individual from showing himself, and to promptly put him out of action if he does show himself. It is their business to deter the enemy from manning his light guns, to throw a hail of projectiles into his ports, and to riddle his unarmored parts. When this business is, *ab initio*, thoroughly carried out by the light guns of one party to an action, the light guns of the other party become useless. They cannot be fought. Even the heavy guns can only be fought with difficulty, owing to the storm of small projectiles that enters every port, and works destruction and death within. And in the meanwhile the people in the unarmored parts of the vessel are suffering severely, both from the fire and from the consciousness that they are unable to make effective reply. It was undoubtedly to the excellence of their light gun-fire that the Chilians owed most of their naval successes in the war with Peru. At the battle of Iquiqui, the Esmeralda's fire, up to the very moment when she sank, was extraordinarily fierce. Captain Grau, of the Huascar, afterward spoke of the Esmeralda having used mitrailleuses. Unfortunately for herself, she had no machine gun of any kind. It was the intensity of her rifle fire that misled the heroic Grau, who himself confessed that, so demoralized was his crew, had Captain Prat, of the Esmeralda, boarded him with a score of men, instead of with only one seaman, the Huascar would probably have been carried.

In the fight between the Shah and the Huascar, a Gatling gun in the former's foretop effectually drove the crews from the two 40-pr. and the one 12-pr. guns on the latter's quarter deck. Mindful of this, Grau, in the summer of 1879, caused a Gatling, protected by an iron screen, to be fitted in the Huascar's maintop; but at the battle of Angamos the crew of this gun were killed or driven below by the rifle fire from the Cochrane, and, as in the earlier action, the quarter deck guns were also subjected to so hot a fire that they could not be served.

The Chilians on this occasion had twelve picked marksmen stationed in the foretop and maintop respectively of both the Cochrane and the Blanco Encalado, and, in addition, used Nordenfelt guns. The result was that no one who showed himself on board the Huascar escaped unhurt. Eighty officers and men out of her crew of 200 were killed or wounded.

A Chilian officer who was present has since expressed his opinion that the victory of Angamos was distinctly attributable to the fact that the Chilians, from the very commencement, obtained and preserved the superiority in light gun-fire.

This is saying a good deal, seeing that on that day the Peruvians were two against six, or, so far as the ships actually in hot action were concerned, one against two.

"It is worthy of note," says Lieutenant Mason, "that while the Chilian vessels could always bring some of their guns to bear on the Huascar, the Huascar found herself in many positions where only sheering would bring her guns to bear on them."

This was because the Huascar, having lost the superiority in light gun-fire, was able only to use the two 10-in. 12½-ton guns in her turret. She could not fight her unprotected guns at all after the first few minutes. The Cochrane and the Blanco Encalada, on the other hand, having silenced the Huascar's light guns, were able to bring all their armament into play. This was, in the case of each, six 9-in. 12-ton guns, one 20-pr., one 9-pr., and one 7-pr., supplemented in the case of the Blanco by two, and in that of the Cochrane by one, 1-in. Nordenfelt machine-gun, and in both cases by riflemen in the tops.

Immediately after the battle, Hotchkiss revolving cannon were fitted in both vessels. Light gun-fire played an equally important part in China and at Alexandria. In China it prevented the enemy, both ashore and afloat, from using his guns to good advantage; at Alexandria it drove the Egyptians from the casemates, or killed gun's crew after gun's crew that remained at its post. In fact there are good reasons for believing that where two forces are otherwise anywhere nearly equal, the force which earliest obtains and preserves the superiority in light gun-fire will ultimately be the victor; and this being so, the multiplication of quick-firing and machine-guns in British men-of-war is, apart from other arguments in favor of it, earnestly to be desired.

The quick-firing gun is, however, not exclusively a murderous and preventive weapon. It also takes rank among heavy guns, and among pieces that are designed for the destruction of material. And this applies as well to 3-prs. and 6-prs. as to 14-prs. and to 4·72-in. and 6-in. quick-firing guns. According to a statement in a paper on "Quick-firing Guns for Fortress Defense," by Captain F. G. Stone,* R.A., at Eastbourne, a shell from a 6-pr. Hotchkiss "struck the chase of a 10·4-in. breech-loading gun and penetrated into the bore;" and "at Shoeburyness a 9·2-in. breech-loading gun was struck on the chase and a bulge of nearly half an inch was raised on the interior of the bore, thus rendering the weapon unserviceable." Every one does not perhaps know what the big guns which were thus easily damaged are like, and how important a feature they form in the armament of vessels in which they are mounted. The so-called 10·4-in. breech-loader was, presumably, a 29-ton gun, 26 ft. 8 in. long; the 9·2-in. breech-loader weighs 22 tons, and is over 24 ft. long. Both are guns such as form part of the primary armament of several of our battleships, and they are so heavy that not more than two or four of them can easily be carried in any vessel. If mounted *en barbette*, they are altogether exposed. If mounted in a turret, about one-third of their length is unprotected, and their length practically precludes their being mounted on disappearing carriages, save in ships that may be specially built for them. Thus these large guns are necessarily very vulnerable, and, seeing that there are in existence scores of warships that are capable of firing from their quick-firing guns from 100 to 200 projectiles a minute, and that these quick-firing guns are singularly accurate, it is not unreasonable to suppose that in the next great naval engagement a number of heavy guns will be put out of action, as well by the destructive as by the murderous effect of quick-firing guns. Quick-firing guns of the larger calibers are, of course, of too recent introduction to have been practically tested on a grand scale in naval warfare, but in his comments on the battle of Angamos, Lieut. Mason, speaking of the small guns of the Hotchkiss and Nordenfeldt types, points out that they had already proved themselves effective, not only against the *personnel*, but also against the *materiel*. Admiral Albini, the distinguished Italian specialist, has fully recognized the importance of quick-firing and machine guns in the preparation of his latest designs for battleships and cruisers. He would give his ideal battleship four heavy guns, eighteen 6-in. guns, and no fewer than twenty-eight quick-firing and fifty machine guns; and to his ideal first class cruiser he would give thirty 6-in. and twenty quick-firing guns. A battleship such as Admiral Albini's should have no difficulty in obtaining and preserving a superiority in light gun-fire over any vessel in existence. Having established that superiority, she could at leisure knock her enemy to pieces.

As regards heavy guns—guns, that is, of over 6-in. caliber—the lessons of the last thirty years seem to be entirely in accordance with the principles enunciated by the committee on naval designs, and in a more uncompromising tone by Rear-Admiral R. A. E. Scott. The committee on naval designs said, in effect, that the ideal heaviest gun for battleships should be of "about 50 tons in weight." The conclusion was arrived at on the score of the overwhelming importance of lightness, handiness, durability, rapidity of manufacture and relative cheapness. Admiral Scott goes further, and thinks that a 30-ton gun is as big a weapon as it is needful to mount in any ship. When we consider how very few heavy guns can be borne by any ship, how disastrous and yet how easy would be the disablement of any one of them, how impossible it is to work a very heavy gun except by machinery, how lamentably short, at best, is the life of a very heavy gun, and how great is the cost of gun and charge, how many projectiles are necessarily thrown away when fired from a platform so unsteady as that which is afforded by a ship at sea; how terribly the firing of a very heavy gun shakes a vessel, and how important it is to have many guns rather than few—when, I say, we consider all these things, it is difficult to resist the conviction that Admiral Scott is right. Theoretically, a 10 in. 30-ton gun should be able to pierce a thickness of 23 in. of armor at the muzzle, or a thickness of over 21 in. of armor at 1,000 yards. That appears to be all that is necessary. Very few vessels indeed have armor that anywhere exceeds 18 in. in thickness, and even they have it only over very limited areas. One and all of them could undoubtedly be put out of action, and even sunk, without their armor being once touched. A penetration of 18 in. at 2,000 yards seems, therefore, to be all that we need ask for. Our 10-in. 29-ton gun at that range can pierce 19½ in. with a full charge, and it possesses the immense advantage of being workable, in case of need, by hand. Besides this, it is relatively cheap, durable,

* See *Journal of the Institution*, No. 147, page 9.

and quickly manufactured, and, if ships were specially designed for it, could be easily mounted on a disappearing carriage. "Disappearing guns firing *en barbette*," says the American Captain Goodrich, in his official report on the bombardment of Alexandria, "are very efficient." Nor is it difficult to understand why. They can often be fought even when the superiority of light gun-fire has been lost, for their crews may always be under protection.

But experience shows that too much may be sacrificed for the sake of heavy guns, though they be by no means of the largest caliber. Let us, for example, take the case of the Shah as she was at the time of her battle with the Huascar, in 1877. The Huascar's thickest armor was 7½ in. on parts of her turret, 5½ in. on other parts, and 4½ in. on the sides. The Shah's heavy guns were two 9-in. 12-ton, sixteen 7-in. 6½-ton, and eight 64-prs., all rifled muzzle loaders. At 3,000 yards, or less, any one of the eighteen larger guns should, theoretically, have been well able to pierce every part of the Huascar's side armor. The engagement took place for the most part at ranges varying, according to Chief Engineer King, from 1,500 to 2 500 yards, and between seventy and eighty projectiles struck the Peruvian ram, yet her armor was only once penetrated. I put this forward merely because it tends to prove that, even when the best gunners are concerned, an immense amount of heavy gun fire may be fruitlessly expended in an action at sea. The amount of waste is largely dependent upon the state of the sea, and upon the general conditions of the fight. At the battle of Angamos, when the action was of far shorter duration, the Huascar was exposed to the fire of twelve heavy guns of 9-in. caliber, exactly similar in character to the Shah's two largest weapons. It may be said, therefore, that the guns engaged (there were at Angamos no lighter armor-piercing guns) were, roughly, of about the same total power on the two occasions. Yet at Angamos the results, so far as the Huascar was concerned, were very different. She was, according to Mr. H. D. Pender, who visited her after the fight, struck upward of twenty times. At least a dozen projectiles traversed the armor—several in its thickest parts—and burst inside the ship. For example, a shell penetrated the armor of the turret in its thickest part, to the left of the port of the right gun, killing and disabling most of the guns' crews. Another struck the turret near the top, burst in the turret, and killed or mortally wounded every man in it. A third pierced the armor abreast of the engine room, covered the engines with debris, and killed or wounded several persons in the engine room gallery. Here the heavy guns did the work that was reasonably to be expected of them, although probably the gunners were far inferior to those of the Shah. It is a question of conditions. To quote Captain Goodrich again, "The swell tells against the shooting, especially of ships engaging broadside on." The conditions of light and wind also materially influence results, and experience, not only in the South Pacific and at Alexandria, but also in North America, at Lissa, in the Dano-German war, and in China, shows exclusively that it is not always practically possible to make very heavy guns do the work which, in theory, they ought to do with ease. Lighter guns, besides being more quickly aimed, produce less smoke, and involve a less serious expenditure of ammunition, as well as diminished expenditure of exertion. Even if the percentage of hits be no greater, the actual number of hits is always larger, and in a day like the present, when at 2,000 yards a 6-in. B. L. gun will theoretically penetrate 8½ in., a 4·72 quick-firing gun over 7 in., and a 14-pr. quick-firing Nordenfelt nearly 5 in. of armor, the destructive value of comparatively light guns cannot be sneered at.

To officers taking their ships into action, the general lessons of the last thirty years of naval warfare seem, to sum up, to be very clear and explicit. The more important of them may be thus set forth:

1.—Let your first object be to establish and maintain a superiority in light gun-fire over your enemy. Open fire early with quick-firing and machine guns so as to drive the hostile crew from the decks, the tops, the unarmored structures, and the neighborhood of the ports. Do not omit, too, to devote attention to the exposed parts of his heavy guns, to funnels, and to the sighting hoods on his turrets or near his barbettes.

2.—As you decrease your distance, say to 2,000 yards, open fire with your medium guns, *e. g.*, your 6-in. guns, especially on his unarmored ends, on his conning towers, and on the neighborhood of his wheels, meanwhile keeping up your light gun-fire unintermittently whenever you can see your foe.

3.—Decrease your distance to 1,200 yards—*i. e.*, to what may be called point blank range—ere you open with any gun of more than 6-in. caliber, but never diminish it to less than 600 yards, for fear of torpedoes.

4.—Never attempt to ram. If you try before your enemy is disabled, the chances are as a hundred to one that he will evade you, and perhaps torpedo you as you pass him. If you try after you have disabled him, you may succeed, but you will infallibly injure yourself in the collision, and while you surrender all chance of taking him, you will lay yourself open to his torpedoes. When you have demoralized your adversary, finish him with your heavy guns, still keeping down his light gun-fire and checking his heavy gun-fire by means of your quick-firing and machine guns.

5.—Never pick up any floating boat or other object that might by chance belong to the enemy. It is perhaps a Greek gift.

6.—Be prepared to remedy any mishap to your steering gear. The immediate cause of the loss of the Independencia, the Huascar, the Re d'Italia, and many other vessels, was the sudden disabling and tardy repairing of the steering arrangements.

To naval constructors and to those who are responsible for the armament of war ships, the practical lessons of the past are even clearer, but they have already been sufficiently suggested. Shortly put, they are: Armor your vitals, protect your guns' crews, have a large secondary armament, avoid very heavy guns, and put such heavy guns as you retain on disappearing carriages, so that they may fire *en barbette*, and be worked, if necessary, by hand.—*Jour. Royal United Service Institution.*

IT is reported that a diet of fresh, sweet buttermilk has been often found favorable, and even effectual, to the cure of Bright's disease.

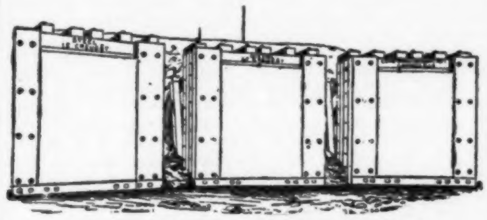
ANNAPOLIS ARMOR TRIAL.

THE tests of armor begun at the naval ordnance proving grounds, Annapolis, under the supervision of Commodore Folger, Chief of Ordnance, on the 18th of September, and continued and concluded on the 22d, were not only by far the most important ever held in this country, but were among the severest ever made anywhere in the long contest for supremacy between target and gun. The extent of the victory won by nickel-steel in this trial can be best shown by the illustrations herewith presented of the rival plates as they appeared at the end of the competition.

The plates tested were a compound plate having a hard steel face and wrought iron back, made by Charles Cammell & Co., of Sheffield; a forged steel plate made by Schneider & Co., of Le Creusot; finally, a plate also from Le Creusot, made from an alloy of steel with about 3¼ or 3½ per cent. of nickel.

The two most famous firms making compound armor in England are John Brown & Co. and Charles Cammell & Co., both of Sheffield. The former employs the patent of John D. Ellis, its managing director; the latter, the patent of George Wilson, also its managing director. Lieut. W. H. Jaques, formerly of our navy and now of the Bethlehem Iron Works, gives this description of the mode of manufacturing compound plates by Cammell and Brown:

The iron back is made by the ordinary method of manufacturing wrought iron plates, and is common to the two establishments. The method at present em-



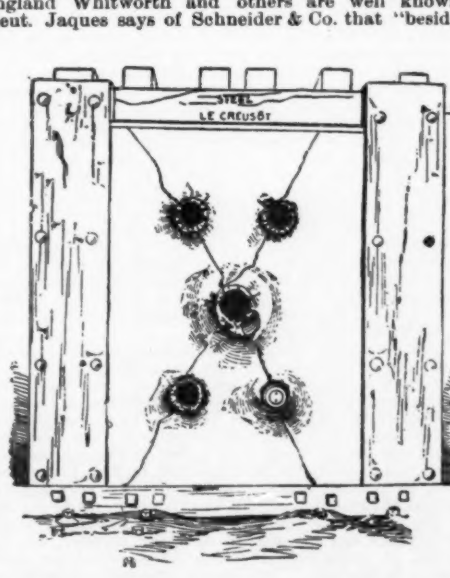
THREE PLATES BEFORE FIRING.

ployed by Brown is to lay the forged steel face plate over the wrought iron plate, from which it is separated by a wedge frame round three sides, and rows of steel blocks called distance pieces. Thus prepared, they are carried to the heating furnace, where, after covering all exposed steel surfaces with gannister, they are raised to the proper temperature and transferred to a vertical iron pit, where a hydraulic ram holds all the parts securely and prevents the bulging of the face plate. Molten steel, either Bessemer or open hearth, is then poured into the space between the plates, and after sufficient time has been allowed for it to solidify, the whole is placed in a hydraulic press of 6,000 tons capacity and the thickness reduced about three inches. The plate is then finished by reheating, passing through the rolls, bending, planing and fitting it for the service required.

Cammell heats the wrought iron plate to the required temperature, and rolls it into an iron mould that works on trunnions. The mould is then lifted by a crane to a vertical position and landed into a pit, where it receives the open hearth or Bessemer steel which is to constitute the hard face. After solidifying, the plate is finished in the rolls.

Two-thirds of iron and one-third steel are still accepted as the best proportions. Both methods give practically the same results under fire. Major Mackinley, R. A., writes, 1885: "Ellis' plan has the advantage of a very good front surface, but the results attained by each are generally considered to be about the same as far as present experience has shown."

The most famous producers of steel armor are Schneider & Co., of Le Creusot, in France, while in England Whitworth and others are well known. Lieut. Jaques says of Schneider & Co. that "besides

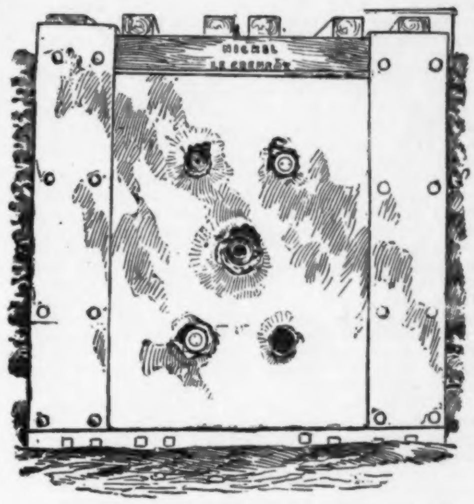


ALL-STEEL PLATE AFTER FIVE SHOTS.

possessing methods of composition, tempering and annealing, and treatment generally, which no one has been able to equal, they have a valuable experience that enables them to rapidly increase the efficiency of their production." This last assertion has now been strikingly verified. In manufacturing compound plates one difficulty is that of joining the iron and steel, whereas a Schneider plate is a single ingot of homogeneous metal. These ingots, according to Rear-Admiral Simpson, of our navy, "are cast nearly cubical in form. An ingot of seventy-five tons is usually heated about eight times before being reduced to its final shape, after which the edges are cut off with powerful tools."

According to Lieut. Jaques, the difference of object in the two systems may be described as follows:

"The steel face of compound armor contains about 0·7 per cent. of carbon, and its object is to deform or break up the projectile on impact, while the wrought iron back holds the plate together and keeps the steel up to its work. The iron back is not expected to be of much value in keeping out the shot after it has penetrated the steel face. Major Mackinley, R.A., thinks that compound armor has an advantage because its face is so hard, but considers that the union of the two materials, steel and wrought iron, prob-



NICKEL-STEEL PLATE AFTER FIVE SHOTS.

ably leads to complication and uncertainty in results.

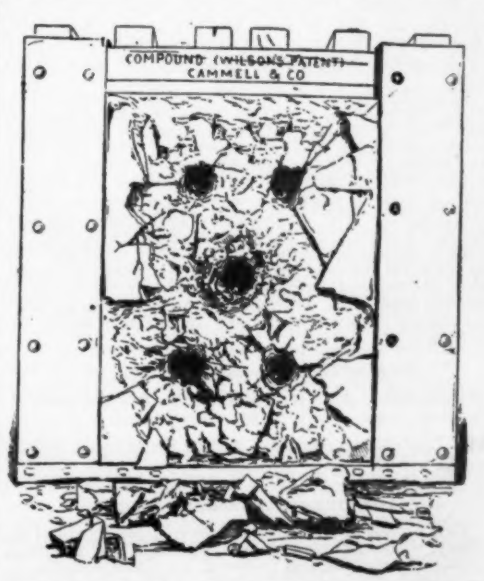
"Schneider steel armor contains about 0·4 per cent. of carbon, and is very carefully tempered. The outer surface of the plate is slightly harder than the inner surface, and the object to be attained is not only to destroy the shot on impact, but to present as great and nearly uniform a resistance as possible throughout the entire thickness of the plate, so that it may hold together till the shot is broken.

"Compound armor, therefore, shows to better advantage, so far as a surface work is concerned, when the projectiles are poor than when they are good."

It only remains to speak of the third plate, the one containing an alloy of nickel. The possibility of obtaining greater tenacity from such an admixture has been a subject of study and experiment in Europe for two or three years. Schneider & Co. found that the tensile tests in certain combinations of nickel with steel were very satisfactory, and it is said that the ballistic tests with small plates yielded promising results.

But no nickel-steel plate of the size used at Annapolis had ever before been subjected to a public competitive trial. It is said that the alloy of nickel in the successful plate is 3·24, with very much smaller percentages of carbon, silicon, and of manganese, but there is no official statement on this point.

The three plates were each 8 feet high by 6 feet wide, the two Schneiders being 10·5 inches thick and the Cammell 10·6 inches. They were bolted to 36 inches of oak backing, well braced with supports. The gun



COMPOUND PLATE AFTER FIVE SHOTS.

used on the first day was a 6 inch naval breech-loading rifle, specially constructed at the Washington ordnance factory for the purpose, and made about 1¼ feet longer than the standard gun of this caliber so as to secure a higher initial velocity. The charge was 44½ lb. of American cocoa powder, which was estimated to give a muzzle velocity of 2,075 feet per second and a muzzle energy of about 3,300 foot tons. At a trial against a similar Cammell plate last spring at Portsmouth, the initial velocity of the British 6 inch gun was but 1,976 feet and the striking energy 2,800 foot tons. The projectiles used at Annapolis were Holtzer

forged steel shells, made at Unieux, in France, 17 in. long and weighing 100 lb. each. The armor plates were ranged on the arc of a circle about thirty feet from the muzzle of the gun.

Twelve shots were fired. First came three aimed in succession at the lower right hand corners of the three plates, then three at their lower left hand corners, three more at the upper right hand corners, while the final rounds were at the upper left hand corners.

The first shot was at the Schneider all-steel plate. The projectile perforated the metal, and its point reached a few inches beyond into the backing, turning up a little ridge of surface metal around the orifice, but leaving the rest of the plate intact.

The next shot was at the Cammell compound plate. It went clean through the plate and was embedded in the oak backing, the point of the shell having penetrated more than two feet into the backing. The plate was splintered around the hole, and seven cracks were visible.

The third shot was at the Schneider nickel-steel plate. The projectile was broken, and part of it flew back twenty-five feet. The point got through the plate and just entered the backing, as in the all-steel plate, and as in that also the only injury to the plate was immediately around the hole.

The second series of shots practically repeated and enforced the story of the first, and so it was with the third and fourth series. In each case the projectile was just about able to pierce the two Schneider plates, or perhaps to go a few inches into the backing, but in no case did either plate show cracks. In one instance the projectile rebounded from the all-steel plate, and in another it was broken, while the nickel-steel plate broke two projectiles. But the Cammell plate suffered more and more from each shot. At the second shot the projectile broke, but the cracks previously showing as dark lines became open fissures, and many pieces of the steel face were torn off. The third shot set the backing on fire and showed a mass of deep cracks in the plate. The fourth shot dismantled the top of the plate, stripping off the steel face from the upper holes and going clear through the target, backing and all, the largest piece of the broken projectile being sunk in the hillside.

The first day's trial thus ended in the practical wreck of the compound plate and the triumph of the two steel plates, with the advantage rather in favor of the nickel-steel, as showing less injury, although it had allowed a little greater penetration of the projectiles.

Four days later the trial was resumed with an 8 inch naval breech loader throwing a 210 lb. shell made by Firth of Sheffield on the Firminy process. Had a fifth shot been given instead by the 6 inch gun, it would have formed an ordinary test; as would have been only two shots with the 6 inch and one with the 8 inch gun. But the test was to be more exhaustive than at first had been intended. However, on account of the short range and the previous weakening of the plates, it was deemed prudent to use only 85 pounds of Dupont's brown prismatic powder in the 8 inch gun, which gave an initial velocity of but 1,850 feet.

The first shot was fired at the center of the all-steel plate. The point of the projectile penetrated it and entered 4⅛ inches into the wood backing, then rebounded, broken into three nearly equal parts. The edges of the hole were splintered, and four cracks radiated from it through the holes made by the 6 inch shots and continued to the corners of the plate.

The second shot was fired at the center of the nickel-steel plate. The point of the projectile reached about 11 inches into the backing, but was badly broken up, about a third of it remaining in the plate. What was most important, there were no cracks anywhere, and the only injury was the ragged edge around the orifice. The third shot was at the compound plate, and inasmuch as it had already been nearly ruined, the projectile went clean through the plate, through three feet of oak backing also, through a part of one of the braces and lodged unbroken 12 feet deep in the packed earth. Almost the entire face of the plate was gone, to the depth of 3 to 5 inches, irregular lumps clinging to the side supports. The wrought iron back of the plate held its place against the oak, but it had, of course, offered little resistance. Fragments of steel flew long distances, and a mass of them dropped in front of the plate.

Thus the trial ended in the victory of the nickel-steel. Save for the 8 inch shot, that victory would not have been so complete, since presumably the all-steel plate would have stood another 6 inch shot very well. The American guns appeared to great advantage, as did also the Holtzer projectile; but the Firth shells did less well. Congress showed its appreciation of the value of this trial by promptly authorizing the purchase of $1,000,000 worth of nickel ore and nickel matte, so as to permit the alloy of nickel in the steel plates to be made for our new ships. This can easily be done, since the Schneider process of making steel armor is the one used at the Bethlehem Iron Works in its large contract with the government for our new navy.—*N. Y. Sun.*

[Continued from SUPPLEMENT, No. 771, page 12320.]

MEETING OF THE BRITISH ASSOCIATION, 1890.

THE INAUGURAL ADDRESS, BY SIR FREDERICK AUGUSTUS ABEL, C.B., D.C.L. (OXON.), D.Sc. (CANT.), F.R.S., P.P.C.S., HON. M. INST. C.E., PRESIDENT.

IMPROVEMENTS IN GUNPOWDER

THE replacement of smooth bore guns by rifled artillery, which followed the Crimean war, and the great increase in the size and power of guns, necessitated by the application of armor to ships and forts, soon called, however, for the pursuit of investigations having for their object the attainment of means for variously modifying the action of fired gunpowder, so as to render it suitable for artillery of different calibers whose power could not be effectively, or, in some instances, safely, developed by the use of the only kind of gunpowder then employed in English artillery of all calibers.

The means resorted to in the earlier of these investigations, and adhered to for many years, for controlling the violence of explosion of gunpowder, consisted exclusively in modifying the size and form of the individual masses composing a charge, and of their density and hardness, with the object of varying the rate of burning of those masses in a gun, it being considered that, as the proportions of ingredients generally employed very nearly correspond to those required for the development of the greatest chemical energy by the thoroughly incorporated materials, the attainment of the desired results should be, if possible, effected rather by modifications of the physical and mechanical characters of gunpowder than by variations of the proportions and chemical characters of its ingredients.

The varieties of powder from time to time introduced into artillery service, as the outcome of investigations in this direction, were of two distinct types: The first of these consisted of further developments of the old granulated or corned powder, being produced by breaking up more or less highly pressed slabs of the material into grains, pebbles or bowlders of approximately uniform size and shape. Gunpowders of this class, ranging in size from about 1,000 pieces to the ounce to about six pieces to the pound, have performed efficient service, and certain of them are still employed.

The character of the other type is based upon the theoretical view that uniformity in the action of a particular gunpowder, when employed under like conditions, demands not merely identity in regard to composition, but also identity in form, size density, and structure of the individual masses of which a charge consists.

To approach the practical realization of this view, equal quantities of one and the same mixture of ingredients, presented in the form of powder of uniform fineness and dryness, must be submitted to a particular pressure, for a fixed period in moulds of uniform size, the surrounding conditions and subsequent manufacturing processes being as nearly as possible alike. Practical experience has, however, shown that uniformity in the ballistic properties of black powder can be even more readily secured by the thorough blending or mixing together of different products of manufacture, presenting some variations in regard to size, density, hardness, or other features, than by aiming at an approach to identity in the characters of the individual grains or masses.

When our attention was first actively directed to the modification of the ballistic properties of powder, the subject had already been to some extent dealt with, in the United States, by Rodman and Dorémus, and the latter had proposed the employment, in heavy guns, of charges consisting of large pellets of prismatic form. While this prismatic powder, which was first used in Russia, was being perfected, and extensively applied there, as well as in Germany and England, the production of powder masses more suitable, by the comparatively gradual nature of their explosion, for the very large charges required for the heavy artillery of the present day, was actively pursued in Italy, and by our own government committee on explosives. The outcome of exhaustive practical investigations being the very efficient Fossano powder, or *poudre progressif* of the Italians, and the bowlder and large cylindrical powders produced at Waltham Abbey.

Researches carried out by Captain Noble and myself, some years ago, with a series of gunpowders, presenting considerable differences in composition, indicated that decided advantages might be secured, for heavy guns especially, by the employment of such a powder as would furnish a comparatively very large volume of gas, its explosion being at the same time attended by the development of much less heat than in the case of ordinary black powder. In the course of these researches much light was thrown upon the causes of the wearing or erosive action of powder explosions upon the inner surface of the gun, an action which, especially in the larger calibers of artillery, produces so serious a deterioration of the arm that the velocity of projection and accuracy of shooting suffer considerably, the wear being especially great where the products of explosion, while under the maximum pressure, can escape between the projectile and the bore. The great velocity with which the very highly heated gaseous and liquid (fused solid) products of explosion sweep over the heated surface of the metal gives rise to a displacement of the particles composing the surface of the bore, which increases in extent as the latter becomes roughened, and thus opposes greater resistance. At the same time, the high temperature to which the surface is raised reduces the rigidity of the metal, and its consequent power of resisting the force of the gaseous torrent. And, lastly, some amount of chemical action upon the metal, by certain of the highly heated, non-gaseous products of explosion, contributes toward an increase in the erosive effects. Experiments made upon a large scale by Captain Noble with powders of different composition, and with other explosives, have afforded decisive evidence that the explosive agent which furnishes the largest proportion of gaseous products, and the explosion of which is attended by the development of the smallest amount of heat, exerts least erosive action.

Some eminent German gunpowder manufacturers, who were at this time actively engaged upon the production of a suitable powder for heavy guns, directed their attention, not merely to an alteration of the proportions of the ingredients but also to a modification in the character of charcoal employed. The eventual result was the production of a new prismatic powder, composed of saltpeter in somewhat higher proportion than in normal black powder, and of a very slightly burned charcoal of reddish brown color, quite similar to the *charbon roux* which Violette produced about forty years ago for use in sporting powder, by the action of superheated steam upon wood or other vegetable matter. This brown prismatic powder (or "cocoa powder") differs from black powder not merely in color. It burns very slowly in the open air, and in guns its action is comparatively gradual and long sustained. The products of its explosion are simple. As the powder contains saltpeter in large proportion relatively to the sulphur and charcoal, these become fully oxidized, and a relatively very large amount of water vapor is produced, partly because of the comparatively high proportion of water in the finished powder, and partly from the large amount of hydrogen in the slightly charred wood or straw used. The smoke from a charge of brown powder differs but little in volume from that of black powder, but it disperses much more rapidly, owing to the speedy absorption of the finely divided potassium salts, forming the smoke, by the large proportion of water vapor through which they are distributed.

This kind of powder has been substituted, with considerable advantage, for black powder in guns of comparatively large caliber, but it soon became desirable to attain even more gradual action in the case of the very large charges required for guns of the heaviest calibers, such as the 110 ton gun, from which shot of about 1,800 lb. weight are propelled by a powder charge of 960 lb. Brown powder has, therefore, been modified in composition to suit these conditions, while, on the other hand, a powder intermediate in rapidity of action between black powder and the brown prism powder has been found more suitable than the former for use in guns of moderately large caliber.

SMOKELESS POWDER.

The importance which machine guns and comparatively large, quick firing guns have assumed in the armament of ships has made it very desirable to provide a powder for them which will produce comparatively little or no smoke, as their efficient employment becomes greatly limited when, after a very few rounds rapidly fired, with black powder, the objects against which it is desired to direct the fire are more or less completely hidden by the interposed smoke. Hence much attention has of late been directed to the production of smokeless, or nearly smokeless, powders for naval use. At the same time, the views of many military authorities regarding the importance of dispensing with smoke in engagements on land have also created a demand for smokeless powders suitable for field artillery and for small arms.

The properties of ammonium nitrate, of which the products of decomposition by heat are, in addition to water vapor, entirely gaseous, have rendered it a tempting material to those who have striven to produce a smokeless powder. But its deliquescent character has been a formidable obstacle to its application as a component of a useful explosive agent. By incorporating charcoal and saltpeter in particular proportions with ammonium nitrate, F. Gaus recently claimed to have produced an explosive material free from the hygroscopic character common to other ammonium nitrate mixtures, and furnishing only permanently gaseous and volatile, or smokeless, products of explosion. These anticipations were not realized, but they led the talented German powder maker, Mr. Heidemann, to produce an ammonium nitrate powder possessing remarkable ballistic properties, and producing comparatively little smoke, which speedily disperses. It yields a very much larger volume of gas and water vapor than either black or brown powder, and is considerably slower in action than the latter. The charge required to produce equal ballistic results is less, while the chamber pressure developed is lower, and the pressures along the chase of the gun are higher than with brown powder. No great tendency is exhibited by it to absorb moisture from an ordinarily dry or even somewhat moist atmosphere, but it rapidly absorbs water when the hygroscopic condition of the air approaches saturation, and this greatly restricts its use.

About five years ago reports began to reach us from France of the attainment of remarkable results with a smokeless powder employed with the repeating or magazine rifle then in course of adoption for military service, and of marvelous velocities obtained by the use of this powder, in specially constructed artillery of great length.

As in the case of the explosive agent called *melinite*, the fabulously destructive effects of which were much vaunted at about the same time, the secret of the nature of this smokeless powder was well preserved by the French authorities. It is now known, however, that more than one smokeless explosive has succeeded the original, and that the material at present in use with the Lebel repeating rifle belongs to a class of nitro-cellulose or nitro-cotton preparations, of which several have been made the subject of patents in England, and of which varieties are also being used in Germany and other countries.

A comparison between the chemical changes attending the burning or exploson of gunpowder, and of the class of nitro compounds represented by gun cotton, at once explains the cause of the production of smoke by the former and of the smokelessness of the latter. While the products of explosion of the nitro compounds consist exclusively of gases and of water vapor, gunpowder, being composed of a large proportion of saltpeter, or other metallic nitrate, mixed with charred vegetable matter and variable quantities of sulphur, furnishes products of which over fifty per cent. are not gaseous, even at high temperatures, and which are in part deposited as a fused solid—which constitutes the fouling in a fire arm—and in part distributed in an extremely fine state of division through the gases and vapors developed by the explosion, thus giving to these the appearance of smoke as they escape into the air.

So far as smokelessness is concerned, no material can surpass *gun cotton* (or other varieties of nitro-cellulose); but, even if the rate of combustion of the fibrous explosive in a fire arm could be controlled with certainty and uniformity, its application as a safe propulsive agent is attended by so many difficulties that the non-success of the numerous early attempts to apply it to that purpose is not surprising. Those attempts commencing soon after the discovery of gun cotton, in 1846, and continued many years later in Austria, consisted entirely in varying the density and mechanical condition of employment of the gun cotton fiber. No difficulty was experienced in thus exercising complete control over the rapidity of burning in the open air. But when the material was strongly confined, as in the bore of a gun, such methods of regulating its explosive force were quite unreliable, as some slight unforeseen variation in its compactness or in the amount and disposition of the air spaces in the mass would develop very violent action.

Much more promising results were subsequently obtained by me by reducing the fiber to a pulp, as in the ordinary process of making paper, and converting this into highly compressed, homogeneous masses of the desired form and size. Some favorable results were obtained at Woolwich, in 1867-68, in field guns, with cartridges built up of compressed gun cotton variously

formed and arranged, with the object of regulating the rapidity of explosion of the charge. But although comparatively small charges often gave high velocities of projection without any indications of injury to the gun, the uniform fulfillment of the conditions essential to safety proved to be beyond absolute control, even in guns of small caliber, and military authorities not being, in those days, alive to the advantages which might accrue from the employment of an entirely smokeless explosive in artillery, experiments in this direction were not persevered in. At the same time considerable success attended the production of gun cotton cartridges for sporting purposes, the rapidity of its explosion being controlled by various methods. Very promising results were also attained with the Martini-Henry rifle and a lightly compressed pulped gun cotton charge, of pellet form, the uniform action of which was secured by simple means.

A nearly smokeless sporting powder had, in the meantime, been produced by Colonel Schultze, of the Prussian artillery, from finely divided wood, converted after purification into a mildly explosive form of nitro-cellulose, and impregnated with a small portion of an oxidizing agent. Subsequently this powder was produced in a granular form, and rendered considerably more uniform in character, and less hygroscopic. It then closely resembled the well known E. C. sporting powder, which consists of a nitro cotton reduced to pulp, incorporated with the nitrates of potassium and barium, and converted into grains through the agency of a solvent and a binding material. Both these powders produce very little smoke compared with black powder, but do not compete with the latter in regard to accuracy of shooting, when used in military arms.

In past years both camphor and liquid solvents have been applied to the hardening of the surfaces of granulated or compressed masses of gun cotton and of this class of its preparations, with a view to render them non porous. In some smokeless powders of French, German, Belgian and English manufacture, acetic ether and acetone have been also used, not merely to harden the granules or tablets of the explosive, but also to convert the nitro-cellulose, in the first instance, into a more or less gelatinous condition, so that it can readily be incorporated with other components and rolled, or spread into sheets, or pressed into moulds, or squirted into wires, rods, or tubes, while still in a plastic state. When the solvent has afterward been removed, the hardened horn-like or somewhat plastic product is cut up into tablets, or into strips or pieces of suitable dimensions, for conversion into charges or cartridges.

Another class of smokeless powder, similar in physical characteristics to these nitro-cellulose powders, but containing nitro glycerine as an important component, has been originated by Mr. Alfred Nobel, the well known inventor of dynamite, and bears resemblance in its physical characteristics to another of his inventions, called blasting gelatine, one of the most interesting of known violent explosive agents. When one of the lower products of nitration of cellulose is impregnated with the liquid explosive, nitro glycerine, it gradually loses its fibrous nature, becoming gelatinized while assimilating the liquid, and the resulting product almost possesses the characters of a compound.

This preparation, and certain modifications of it, have acquired high importance as blasting agents more powerful than dynamite, and are possessed of the valuable property that their prolonged immersion in water does not separate from them any appreciable proportion of nitro-glycerine. The nitro-glycerine powder first produced by Mr. Nobel was almost perfectly smokeless and developed very high energy, accompanied by moderate pressures at the seat of the charge, but it possessed certain practical defects, which led to the development of several modifications of that explosive and various improvements in manufacture.

The relative merits of this class of smokeless powder, and of various kinds of nitro-cellulose powder, are now under careful investigation in this and other countries, and several more or less formidable difficulties have been met with in their application, in small arms especially. These arise in part from the comparatively great heat they develop, which increases the erosive effects of the products of explosion, and in part from the more or less complete absence of solid products. The surfaces of the barrel and of the projectile being left clean, after the firing, are in a condition favorable to their close adhesion while the bullet is propelled along the bore, with the consequent establishment of very greatly increased friction. The latter difficulty has been surmounted by more than one expedient, but always at the cost of absolute smokelessness.

Our knowledge of the results obtained in France and Germany with the use of smokeless powders in the new rifles and in artillery is somewhat limited. Our own experiments have demonstrated that satisfactory results are attainable with more than one variety of them, not only in the new repeating arm of our infantry, but also with our machine guns, with field artillery, and with the quick-firing guns of larger caliber which constitute an important feature in the armament of our navy. The importance of insuring that the powder shall not be liable to undergo chemical change detrimental to its efficiency or safety, when stored in different localities where it may be subject to considerable variations of temperature (a condition especially essential in connection with our own naval and military service in all parts of the world), necessitates qualities not very easily secured in an explosive agent consisting mainly of the comparatively sensitive nitro compounds to which the chemist is limited in the production of a smokeless powder. It is possiola, therefore, that the extent of use of such a material in our ships, or in our tropical possessions, may have to be limited by the practicability of fulfilling certain special conditions essential to its storage without danger or possible deterioration. If, however, great advantages are likely to attend the employment of a smokeless explosive, at any rate, for certain services, it will be well worth while to adopt such special arrangements as may be required for securing these without incurring special dangers. This may prove to be especially necessary in our ships of war, where temperatures so high as to be prejudicial even to ordinary black powder sometimes prevail in the magazines, consequent mainly upon the positions assigned to them in the ships, but which may be guarded against by measures not difficult of application.

The press accounts of the wonderful performances of the first smokeless powder adopted by the French—which it should be added, were in some respects confirmed by official reports of officers who had witnessed experiments at a considerable distance—engendered a belief that a very great revolution in the conduct of campaigns must result from the introduction of such powders.

It was even reported very positively that noiselessness was one of the important attributes of a smokeless powder, and highly colored comparisons have, in consequence, been drawn in service periodicals, and even by some military authorities, between the battles of the past and those of the future. The terrific din, caused by the firing of the many guns and the roar of infantry fire, in heavy engagements, being supposed to be reduced to noise so slight that distant troops would fail to know in what direction their comrades were engaged, and that sentries and outposts would no longer be able to warn their comrades of the approaching foe by the discharge of their rifles. Military journals of renown, misled by such legendary accounts chiefly emanating from France, referred to the absence of noise and smoke in battles as greatly enhancing the demands for skill and courage and as surrounding a fight with mystery. The absence of recoil when a rifle was fired with smokeless powder was another of the marvels reported to attend the use of these new agents of warfare. It need scarcely be said that a closer acquaintance with them has dispelled the credit given to such of the accounts of their supposed qualities as were mythical, and a belief in which could only be ascribable to a phenomenal combination of credulity with ignorance of the most elementary scientific knowledge.

The extensive use which has been made in Germany of smokeless or nearly smokeless powder in one or two special military displays has, however, afforded interesting indications of the actual change which is likely to be wrought in the conditions under which engagements on land will be fought in the future, provided these new explosives thoroughly establish and maintain their position as safe and reliable propelling agents. Although the powder adopted in Germany is not actually smokeless, the almost transparent film of smoke produced by independent rifle firing with it is not visible at a distance of about 300 yards; at shorter distances it presents the appearance of a puff from a cigar. The most rapid salvo firing by a large number of men does not have the effect of obscuring them from distant observers. When machine guns and field artillery are fired with the almost absolutely smokeless powder which we are employing, their position is not readily revealed to distant observers by the momentary vivid flash of flame and slight cloud of dust produced.

There now appears little doubt that in future warfare belligerents on both sides will alike be users of these new powders; the screening or obscuring effect of smoke will, therefore, be practically absent during engagements between contending forces, and while, on the one hand, the very important protection of smoke and its sometimes equally important assistance in maneuvers will thus be abolished, both combatants will, on the other hand, secure the advantages of accuracy of shooting and of the use of individual fire, through the medium of cover, with comparative immunity from detection. Such results as these cannot fail to affect, more or less radically, the principles and conditions under which battles have hitherto been fought. With respect to the naval service, it is especially for the quick-firing guns, so important for defensive purposes, that a smokeless powder has been anxiously looked for; by the adoption of such a powder as has during the past year been elaborated for our artillery, should experience establish its reliability under all service conditions and its power to fulfill all reasonable requirements in regard to stability, these guns will not only be used by our ships under conditions most favorable to their efficiency, but their power will also be very importantly increased

EXPLOSIVES FOR SHELLS.

The ready and safe attainment of very high velocities of projection through the agency of these new varieties of explosive agents, employed in guns of suitable construction, would appear at first sight to promise a very important advance in the power of artillery; the practical difficulties attending the utilization of these results are, however, sufficiently formidable to place, at any rate at present, comparatively narrow limits upon our powers of availing ourselves of the advantages in ballistics which they may present. The strength of the gun carriages and the character of the arrangements used for absorbing the force of recoil of the gun, need considerable modifications, not easy of application in some instances; greater strength and perfection of manufacture are imperative in the case of the hollow projectiles or shells to be used with charges of a propelling agent by the firing of which in the gun they may be submitted to comparatively very severe concussions; the increased friction to which portions of the explosive contents of the shell are exposed by the more violent setting back of the mass may increase the possibility of their accidental ignition before the shell has been projected from the gun; the increase of concussion to which the fuse in the shell is exposed may give rise to a similar risk consequent upon an increased liability to a failure of the mechanical devices which are applied to prevent the igniting arrangement, designed to come into operation only upon the impact or graze of the projected shells, from being set into action prematurely by the shock of the discharge; lastly, the circumstance that the rate of burning of the time fuse which determines the efficiency of a projected shrapnel shell is materially altered by an increase in the velocity of flight of the shell, also presents a source of difficulty.

The fallibility of even the most simple forms of fuse, manufactured in very large numbers, although it may be remote, must always engender a feeling of insecurity, when shells are employed containing an explosive agent of the class which, in recent years, it has been sought, by every resource of ingenuity, combined with intimate knowledge of the properties of these explosives, to apply as substitutes for gunpowder in shells, on account of their comparatively great destructive power.

One of the first uses, for purposes of warfare, to which it was attempted to apply gun cotton was as a charge for shells. But even when this was highly compressed, and accurately fitted the shell chamber, with the intervention only of a soft packing between the surfaces of explosive and of metal, to guard against friction between the two upon the shock of the discharge, no security was attainable against the ignition of the comparatively sensitive explosive by friction established within its mass at the moment when the shell is first set in motion. By the premature explosion of a shell charged with gunpowder, no important injury is inflicted upon the gun, but a similar accidental ignition of a gun cotton charge must almost inevitably burst the arm. The earlier attempts to apply gun cotton as a bursting charge for shells were several times attended by very disastrous accidents of this kind; but the fact, afterward discovered, that wet compressed gun cotton, even when containing sufficient water to render it quite uninflammable, can be detonated through the agency of a sufficiently powerful charge of fulminate of mercury, or of a small quantity of dry gun cotton embedded within it, has led to the perfectly safe application of gun cotton in shells, provided the fuse, through the agency of which the initiative detonating agent in the shell comes into operation, is secure against any liability to premature ignition when the gun is fired. Many successful experiments have been made with shells thus charged with wet gun cotton, which is now recognized as a formidable destructive agent applicable in shells with much less risk of casualty than attends the use of many other of the violent explosive bodies which it has become fashionable, in professional parlance, to designate as "high explosives."

Many devices and arrangements, more or less ingenious and complicated, have been schemed, especially in the United States, for applying preparations of the very sensitive liquid, nitro-glycerine, such as dynamite and blasting gelatine, as charges for shells.

Some of these consist in subdividing the charge by more or less elaborate methods. In others the shell is also lined with some soft elastic packing material and paddings of similar material are applied in the head and the base of the shell chamber, with the object of reducing the friction and concussion to which the explosive is exposed when the projectile is first set in motion.

Such arrangements obviously reduce the space available for the charge in the shell, and the best of them fail to render these explosives as safe to employ as wet gun cotton. In order to avoid exposing shells loaded with such explosives to the concussion produced when propelling them by a powder charge compressed air has been applied as the propelling agent, and guns of special construction and very large dimensions, from which shells containing as much as 500 lb. of gun cotton or dynamite are projected through the agency of compressed air, have recently been elaborated in the United States, where great expectations are entertained of the value, for war purposes, of these so-called pneumatic guns.

A highly ingenious device for utilizing a class of very powerful explosives in shells, without any risk of accident to the gun, was not long since brought forward by Mr. Grusen, the well known armor plate and projectile manufacturer of Magdeburg. It consisted of a thoroughly efficient arrangement for applying the fact, first demonstrated by Dr. Sprengel, that mixtures of nitric acid of high specific gravity with solid or liquid hydrocarbons, or with the nitro compounds of these, are susceptible of detonation, with development of very high energy. The two agents, of themselves non-explosive—nitric acid and the hydrocarbon, or its nitro product—are separately confined in the shell. When it is first set in motion by the firing of the gun, the fracture of the receptacle containing the liquid nitric acid is determined by a very simple device. The two substances are then free to come into contact, and their very rapid mixture is promoted by the rotation of the shell, so that, almost by the time that it is projected from the gun, its contents, at first quite harmless, have become converted into a powerfully explosive mixture, ready to come into operation through the action of the fuse. Although safety appears assured by the system, the comparatively complicated nature of the contrivance, and the loss of space in the shell thereby entailed, place it at a disadvantage, especially since some other very violent explosive agents have come to be applied with comparative safety in shells.

Between four and five years ago intelligence first reached us of marvelously destructive effects produced by shells charged with an explosive agent which the French government was elaborating. The reported results surpassed any previously recorded in regard to violently destructive effects and great velocity of projection of the fragments of exploded shells, and it was asserted that the employment of this new material, melinite, was unattended by the usual dangers incident to this particular application of violent explosive agents, an assertion scarcely consistent with accounts which soon reached us of several terrible calamities due to the accidental explosion of shells loaded with melinite.

Although the secret of the precise nature of melinite has been extremely well preserved, it transpired ere long that extensive purchases were made in England, by or for the French authorities, of one of the many coal tar derivatives which for some years past has been extensively manufactured for tinctorial purposes, but which, although not itself classed among explosive bodies until quite lately, had long before been known to furnish, with some metals, more or less highly explosive combinations, some of which have been applied to the production of preparations suggested as substitutes for gunpowder.

The product of destructive distillation of coal from which, by oxidation, this material is now manufactured, is the important and universally known antiseptic and disinfectant carbolic acid, or phenol. Originally designated carbazotic acid, the substance now known as picric acid was first obtained in small quantities as a chemical curiosity by the oxidation of silk, aloes, etc., and of the well known blue dye indigo, which thus yielded another dye of a brilliant yellow color. To the

many who may regard this interesting phenol derivative as a material concerning the stability and other properties of which we have little knowledge it will be interesting to learn that it has been known to chemists for more than a century. It was first manufactured in England for tinctorial purposes by the oxidation of a yellow resin (*Xanthorrhœa hastilis*) known as Botany Bay gum.

Its production from carbolic acid was developed in Manchester in 1862, and its application as a dye gradually extended, until, in 1886, nearly 100 tons were produced in England and Wales.

Although picric acid compounds were long since experimented with as explosive agents, it was not until a very serious accident occurred, in 1887, at some works near Manchester where the dye had been for some time manufactured, that public attention was directed in England to the powerfully explosive nature of this substance itself. The French authorities appear, however, to have been at that time already engaged upon its application as an explosive for shells. It is now produced in very large quantities at several works in Great Britain and it has been extensively exported during the last four years evidently for other than the usual commercial purposes. Large supplies of phenol, or carbolic acid, have, at the same time, been purchased in England for France, and lately for Germany, doubtless for the manufacture of picric acid, very extensive works having been established for its production in both those countries. It has been made the subject of experiment by our military authorities, and its position has been well established as a thoroughly stable explosive agent, easily manufactured, comparatively safe to deal with, and very destructive when the conditions essential for its detonation are fulfilled.

The precise nature of melinite appears to be still only known to the French authorities. It is asserted to be a mixture of picric acid with some material imparting to it greater power. But accounts of accidents which have occurred even quite recently in the handling of shells charged with that material appear to show that, in point of safety or stability, it is decidedly inferior to simple picric acid. Reliable as the latter is in this respect, its employment is, however, not unattended with the difficulties and risks which have to be encountered in the use, in shells, of other especially violent explosives. Future experience in actual warfare can alone determine decisively the relative value of violent explosive agents, like picric acid or wet gun cotton, and of the comparatively slow explosive, gunpowder, for use in shells. It is certain, however, that the latter still presents distinct advantages in some directions, and that there is no present prospect of its being more than partially superseded as an explosive for shells.

With regard to submarine mines and locomotive torpedoes, such as those marvels of ingenuity and constructive skill, the Whitehead and Brennan torpedoes, the important progress recently made in the practical development of explosive agents has not resulted in the provision of a material which equals wet compressed gun cotton in combining with great destructive power the all-important essential of safety to those who have to deal with these formidable weapons, and to man the small vessels which have to perform the very hazardous service of attacking ships of war at short distances by means of locomotive torpedoes.

BLASTING EXPLOSIVES.

Although the subject of the development of explosive force for purposes of war has of late received from workers in applied science, from seekers of patentable inventions, and even from the public generally, a somewhat predominating share of attention, considering that we congratulate ourselves upon the enjoyment of a period of profound peace, yet the production of new explosive agents for mining and quarrying purposes, which present or lay claim to points of superiority over the well established blasting agents, has been by no means at a standstill. For many years the main object sought to be achieved in this direction was to surpass, in power or adaptability to particular classes of work, the well known preparations of nitroglycerine and gun cotton, which, during the past twenty years, have been formidable competitors and in many directions absolutely successful rivals, of black powder. It is both interesting and satisfactory to note, however, that this object has of late, and especially since the publication of the results of labors of English and foreign commissions on the causes of mine accidents, been prominently associated with endeavors to solve the important problems of combining, in an explosive agent, efficiency in point of power with comparative non-sensitiveness to explosion by friction or percussion, and of securing its effective operation with little or no accompaniment of projected flame. Safety dynamites, flameless explosives, water cartridges, and other classes of materials and devices connected with the getting of coal, the quarrying of rock, or the blasting of minerals, have claimed the attention of those who guide the miner's work. In some of these directions the practical results obtained have been beyond question important, and, indeed, conclusive, as regards the great diminution of risks to which men need be exposed in those coal mines where the ordinary use of explosives, although not altogether inadmissible, may at times be attended with danger. It is to be feared that those results are still far from receiving the amount of application which might reasonably be hoped for. But, at any rate, there are, among the extensive mining districts where the employment of explosives in connection with the getting of coal cannot be dispensed with, several of importance where the use of gunpowder has almost entirely given place to the adoption of blasting agents or methods of blasting, the employment of which is either not, or only very exceptionally, attended by the projection of flame or incandescent matter into the air where the shot is fired.

The mining public is especially indebted to German workers for much of the success which has been obtained in this direction, and also to the eminent French authorities, Mallard and Le Chatelier, for their thorough theoretical and practical investigations bearing upon the prevention of accidental ignition of firedamp during blasting operations. Having arrived at the conclusion that fire damp and air mixtures are not ignited by the firing of explosive preparations which develop by their detonation temperatures lower than 2220° C., they found that ammonium nitrate, although in itself susceptible of detonation, does not develop a higher temperature than 1130° C., while the temperature of detonation of nitro glycerine and gun cotton are, respectively, 3170° and 2636°. The admixture of that salt with nitro-glycerine or gun cotton in sufficient proportion to reduce the temperature of detonation to within safe limits allows, therefore, of the employment of those explosive agents in the presence of fire damp mixtures without risk of accident, and this fact has led to the effective use of such mixtures as safe blasting agents in coal.

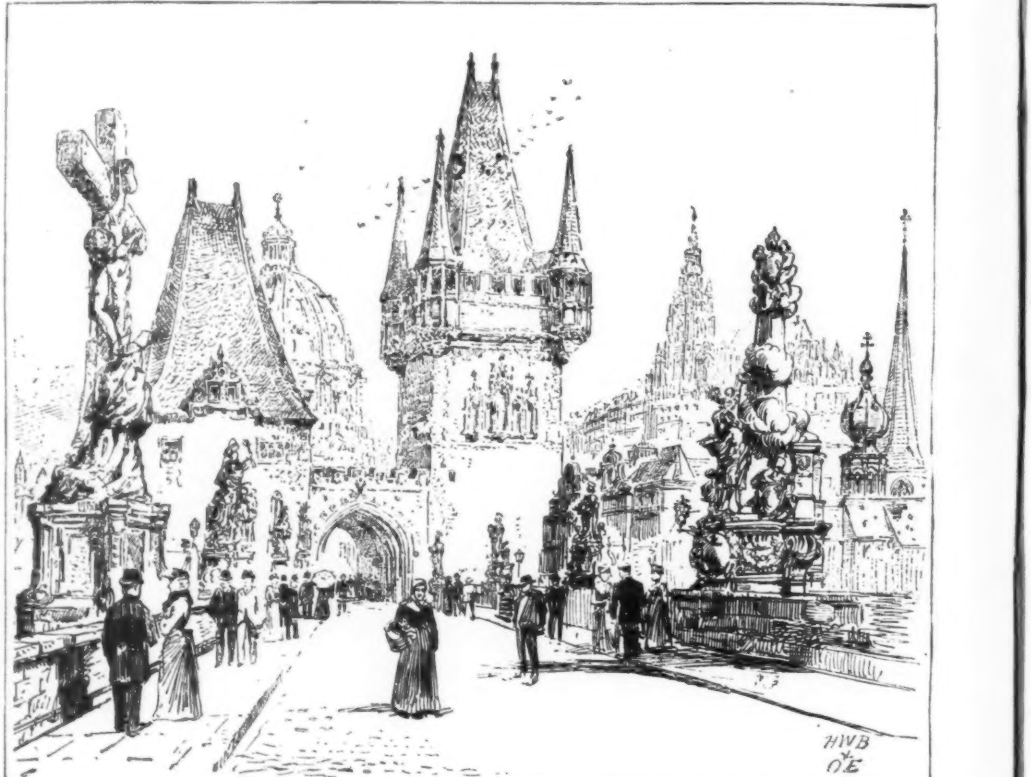
(*To be continued.*)

THE BRIDGE OF PRAGUE.

THE bridge of Prague, which has suffered so much from disastrous floods, is without doubt the finest mediæval bridge in the world, and—until these recent floods—intact and perfect. It is 1,570 German feet in length, and is protected at each end by great watch towers. Figures of saints stand upon the parapets over each pier, and its extraordinary picturesqueness has exercised a fascinating charm over artists, from Prout to Ernest George.

ITS HISTORY.

History and legend are strangely mingled in this bridge. History relates that the watch tower on the Altstadt side, the largest and oldest half of the city, alone maintained the city against the Swedes during the Thirty Years' war. The further half of the city, the Kleinseite, was captured, the watch tower on that end of the bridge passed, and the Altstadt almost reached, when some Jesuit students rushed from the Clementinian College adjoining the larger watch tower of the bridge, and dropped the portcullis. The siege was kept up for more than three months, but the tower saved the town.



THE BRIDGE OF PRAGUE, THE CENTRAL ARCH OF WHICH HAS BEEN SWEPT AWAY BY THE FLOODS.

LEGENDARY LORE.

The legendary share of the bridge's history is more extraordinary still. A confessor of the Queen of King Wenceslaus IV., of Bohemia, refused to divulge the secrets of the confessional, and was thrown by the king's orders into the Moldau from this bridge, and the spot over the river was marked by miraculous flames for three days. Thousands of persons annually crowd into Prague for the festival of this confessor, known as St. John Nepomuk, the patron of bridges. The pilgrim processions of quaintly costumed Bohemians, with banners, filing on to the bridge under the towers in slow step, chanting their litanies, are most striking, and the devout passer-by, on ordinary occasions, kisses the spot on the parapet, marked by five stars, from which Nepomuk was drowned. The martyrdom was said to have taken place in 1383, but canonization not until the eighteenth century. The statue to him was erected in the seventeenth century.

A PROVED FABLE.

The whole legend is stated to be "a proved fable" and "late invention," but the picturesqueness of the statues and processions, and the whole mediæval aspect of the fine old bridge do not suffer in consequence. There are as a contrast two very graceful iron suspension bridges, built by English engineers, above and below the old bridge, which do not at all mar the exquisite landscape of the Moldau Valley, in which the beautiful city of Prague nestles.—*Daily Graphic.*

[FROM SCIENTIÆ BACCALAUREUS.]

THE BEGINNINGS OF MATHEMATICS.

By Prof. W. B. RICHARDS.

Qui currit, legat.

THE human mind is not content with the fact, it desires to know the process. The youth who vivisected the bellows in order to discover the cause of its action is a type of his kind. "Nothing is covered that shall not be revealed;" this is not the least of the joys that await the faithful. To unravel the tangled skein of mysteries that weave us about, to bring the hidden to light, to illumine the dark places, to rescue from the unknown some of its treasures—this has been the incentive that has animated man in every age, has raised his "clear spirit" to "scorn delights and live laborious days," has urged him forward from point to point of achievement. It is the spirit that inspired the wonder working mind of Aristotle, lit "the lonely lamp of Erasmus," and smoothed out "the restless bed of Pascal." The thirst of discovery, like Io's gad fly, will not let man be; it goads him like Jove's ill-fated favorite into restless wanderings through all the obscurest corners of the earth, and all the trackless fields of intellectual research. It wafted the ships of Columbus toward the western world, led De Long to his frozen grave in the wastes of Siberia, and has lately sent Stanley across deserts, over mountains, through savage tribes to the heart of the Dark Continent. Nor has its influence been less present in the intellectual world than in the sensible. Needless to call the honor roll of great minds that attest it. The mind knows no rest. The horizon of its aspirations recedes as it is approached. Its stopping points are only night camps, wherein it prepares for the morrow's march. It may need to intrench itself against the powers of doubt and unreason, but it does not find an abiding place. It never reaches the end. Nor can it. Truth is infinite. A Newton about to die protests sorrowfully that he "has only been picking up pebbles beside the great seashore." At the same time that we aspire to add to the world's mental enrichment, it cannot fail, it seems to me, to be both helpful and interesting to consider the steps by which what we have has been won. It is for this reason that we design to set down in a shape suited to general readers some account of the beginnings of that science which contains within itself the germs of all other sciences.

The student of the mathematics of to-day may well be astounded at the vastness of the field which is open to him, at the multitude of directions in which investigation has been pushed, and the wonderful achievements that have been made in each. If, in the midst of his gratulation upon modern attainments, there is, however, danger of his conceiving a contempt for the lesser success of earlier workers, he should reflect that, if we see farther into the mysteries whose solution has been the problem of all ages, it is not necessarily because our intellectual vision is so much more acute, but partly, at least, because, as has been said, "we stand upon the shoulders of giants." The superiority of modern mathematics over the ancient does not so much arise from a comparison of the body of truth acquired as it follows from the discovery of new methods—the improvement in *technique*, as it were. We do not build structures larger than the pyramids, but we know how to build them more easily. One who reads the history of mathematics wonders not more at the advancement which the moderns, having all the experience and the result of the labors of their predecessors to guide them, have made than at the great fund of mathematical knowledge which the old Greeks were able to master with the means at their disposal. It

was a pure triumph of unassisted mind. Imagine yourself deprived of all knowledge, if not quite of algebraic processes, yet of algebraic notation, which is a chief element of the strength of algebra. Conceive yourself unable to use a symbol for a quantity or a complex combination of quantities, to use + or — or to write an equation. Think how greatly the difficulty of an abstruse problem would be increased. Yet with such negative disadvantages did the ancients work. They were too busy getting out the rich ore from the mine that had been opened to them to stop to sharpen their tools or exchange them for new ones. Where they advanced laboriously in their rude but forceful way, we touch off a little calculus under the obstacle and—piff!—it is gone. But what treasures did they uncover! What might they not have done if their *finesse* had been equal to their strength!

To one who has not previously considered the subject, the antiquity of most of the mathematics ordinarily taught in our colleges is surprising. The elementary geometry is practically as left by Euclid twenty-two hundred years ago. In England translations of Euclid's work are used, while on the Continent and in this country the text books are adaptations of his work. Algebra is a comparatively modern growth, having been introduced into Europe in the thirteenth century, while its symbols were all invented in the last four hundred years. The solution of equations of the second degree, with general coefficients, however, was effected by the Hindoos, certainly as early as Aryabhata in the fifth century A. C., and perhaps earlier. Our analytic geometry is the product of the wedding of the geometry of the Greeks and the algebra of the Hindoos, brought about by Descartes in the first half of 17th century, but the method of analysis may be traced back to the school of philosophers immediately following Plato, while most of the properties of the conic sections were known to Apollonius—the "Sublime Geometer," as he is called by Geminus—and are announced by him in his "Treatise on Conics" (3d century B. C.) The infinitesimal calculus could not arise without algebra, and its invention was the second great fruit borne by that science in the seventeenth century; but the germs of its fundamental analysis are to be found in Archimedes' "Method of Exhaustions," and many of the practical problems to which it is applied—such as the quadrature of surfaces, the cubature of volumes, the calculation of the value of π—were successfully attacked by the early Greek mathematicians. One of the greatest of modern mathematicians pays a just tribute to one of the greatest of the ancient, when Leibnitz says, "Those who can understand Archimedes admires less the discoveries of the greatest moderns." Even what is known as modern geometry is not altogether so recent as might be imagined from the name. Some of the fundamental theorems concerning transversals are enunciated and demonstrated by Pappus, who lived in the 4th century A. C. This is six hundred years later than Euclid's geometry, but only in the most relative sense could it be called modern. The same writer announces without demonstrating the theorems connecting the surface and volume generated by the revolution of a plane curve about an external axis in its plane with the path described by the centroid of the perimeter and area respectively—usually cited as Guldin's theorems. It is not our purpose to institute any invidious comparison of the merits of the ancient and of the modern mathematicians, similar to that which in the field of letters fomented the celebrated controversy that two hundred years ago divided English men of learning into hostile camps, but a suggestion of the respectable and even admirable attainments of antiquity may stimulate an interest in the discussion which we propose.

Mathematics is a comprehensive term which imports very different things to different people. To the child just beginning to wrestle with arithmetic, it probably means the multiplication table and an outlying unexplored territory of unknown dimensions. To the average "young ladies' seminary" "young lady," it means—or it used to mean, for late years have shown an improvement in this respect—arithmetic, some dalliance with algebra, the memorizing of certain portions of Euclid, and perhaps a faint suspicion of trigonometry, the prevailing idea of this subject being that it is something in the back of geometry. To each of us, perhaps, it means as much as he knows, a good deal that he suspects, and a great deal more that he would like to know. Mathematics is the generic name popularly applied, not merely to the labored and difficult processes of a Newton or a Laplace, but as well to the first slate scribblings of the primary scholar. Including thus that which pertains so closely to our earliest mental feats, we might suppose that in order to get to the beginnings of mathematics it would be necessary to go back very nearly to the beginnings of things—to the time "when Adam delved and Eve span." Our introduction to numerical calculation occurs at so early a stage in our experience, it is so nearly contemporaneous with the utmost backward reach of memory, that it is not strange if our proneness to judge others by ourselves leads us to infer that the same notions came to primal man at a correspondingly early period in his history—indeed, were a natural and necessary outgrowth of his mentality.

That these presumptions are erroneous is sufficiently indicated by the facts which we are about to adduce. Percepts antedate concepts. The mind of early man doubtless proceeded, like that of children, by the inductive method—ascending from the cognition of particular facts to the intuition of general laws. We think by means of pictures more or less clearly photographed on the mental curtain. These pictures are either of the things themselves, or, especially in the case of an educated person, of the names or the symbols of the things thought. Try to recall some familiar quotation, and memory, repeating the original process of thought, will bring before the mental vision either the scene or action described, or, it may be, the lines as printed in the text from which you learned it. Say over those lines in which Virgil tells how Priam fell at the foot of the altar that streamed with the blood of his slaughtered son, and either you shall see the sad scene enacted before your mind's eye, or, it may be, there will pass before you the lines of some old dog-eared copy of the Augustan epic, from which, in school boy days, you droned out your task. It is easier to think of concrete, sensible objects than of the abstract, because of the former we may make a definite picture. We take advantage of all this in educating children. We fill their books with pictures. In teaching a child the rudiments of arithmetic we ask him at first not "How much are 5 and 3?" but "How many apples are 2 apples and 3 apples?" or "How many marbles are 2 marbles and 3 marbles?" enabling him to make a picture out of the problem, and asking him to tell just what he sees. Thus we lead him inductively to the notion that two and three make five independently of the nature of the substance numbered. The unaided human mind, working out its own destiny, it may be assumed, made its tedious progress over a similar track. The primal man, as he drove in succession two pairs of oxen into a corral, was aware of a quadrupleness of objects, though he did not as yet separate in his mind the number from the things numbered. It was a long step from this single experience or a great number of such experiences to the dawning of the abstract law that two and two make four—whether it be of oxen or what not. When the idea of abstract number had begun to stir, the next thing would be to find names for the numbers, and no great advance in such thought could be made until the invention of words to indicate number made mental combination of numbers possible. That we are correct in inferring that this development of the idea of number was not necessary nor immediate, is shown by the fact that tribes are to be found at the present time which have not attained such advancement. The Chiquito, the language of the natives of Eastern Bolivia, is said to be absolutely destitute of numerals. Counting is unknown to them. The word that comes nearest to meaning "one" is that which signifies "itself" or "the same;" beyond this point the mathematical ability of these children of nature does not go. Their mind surrenders at the difficulty of grasping so large a number as two, and expresses it and all greater multitude by the indefinite word for "many." The Papuans of Torres Strait have names for only one and two. The Bushmen of Australia are scarcely more advanced. Their numeral system ends at three. The traveler Pelleschi relates that on the plains known as El Gran Chaco, in South America, he encountered a chief who could not count his own fingers. Theon, of Smyrna, one of the earliest writers on arithmetic, states that "Agamemnon was so ignorant of the names of numbers as not to know that he had two feet." The same writer reproaches Pythagoras, Archytas and Philolaus for not having distinguished between "unity" and the number "one"—between the numbers of objects and the objects themselves. "Six oxen," says he, "constitute a sensible number; six is an intellectual number." We thus have abundant evidence that the idea of abstract number was slow in taking shape, and that any adequate system of numerical nomenclature was the result or the concomitant of a considerable mental progress.

Before this had been achieved, when the question, "How many?" was asked, the answer would naturally be given by indicating a corresponding number of some other convenient objects. The ready means of replying to such questions seemed made to hand—we use the expression in good faith with no intention of punning—in the ten fingers. Nothing could be more natural than that the untutored savage, in the absence of vocables suited to the purpose, should call the fingers to his aid in conveying numerical ideas. We, today, very commonly use the same artifice when we wish to present such information silently, while for the deaf, as is well known, a digital alphabet has been invented. The arithmetic neophyte is with great difficulty to be restrained from the pernicious habit, when called upon to "do sums" in addition, of using his fingers as a kind of restricted abacus. The Wallachian peasant is said to perform all multiplications above 4×4 with the assistance of his fingers.

The use of the fingers in this connection affords the reason that the numerical systems of all civilized nations are decimal. Traces of the connection between the assumption of ten as a radix and its occurrence as a natural number are to be found in various languages. In the Polynesian, *lima*, *i. e.*, "hand," means five; in the Zulu, *tatikitupa*, "taking the thumb," signifies six; in Greenlandish, *arfersanek pingasut*, *i. e.* "taking the other foot three" (the two hands = 10, one foot = 5, and 3) means eighteen. In the Maya dialects of Central America the word for twenty is *hun vrinak*, one man; that is the number of fingers and toes belonging to one person. Similarly in New Caledonia the word for man means twenty, while "five men" means one hundred. In English, likewise, the old fashion of counting by scores smacks of the same origin—with which we may compare the French way of expressing ninety-three, for instance, by *quatre vingt-treize*, four twenties plus thirteen. The word that we use for the figures of a number—digit—is directly from the Latin *digitus*, a finger, and indicates the same connection.

These primitive movements in the direction of mathematical cognition are only to be considered the beginnings of mathematics in the same relative sense in which the first stone thrown was the beginning of ballistics, or the first tree hewn across a ravine was the beginning of engineering. For the origin of mathematics as a science we must look to the Greeks—to that prolific national mind to which all the learning of the West may be traced as to its spring. In the domain of learning all roads lead back to Greece. The beginnings of whatever is worthiest in literature, in philosophy, in art, in science, were made by the marvelous people who have given us the epic of Homer, the logic of Aristotle, the sculptures of Phidias, and the geometry of Euclid. No tribute of admiration can be too high to express a just sense of our indebtedness for the imperishable legacy which we have inherited from them. There is no part of the world's wealth to-day with which it might not better part than with its attainments in those departments of mind in which the earliest impulse, and frequently the most lasting monuments, were the products of Hellenic thought. The distinctive features of the Greek intellect were just those which were best suited to grapple with the problem that confronted them. This problem was twofold—the extension of knowledge and the formation of truth into a connected system. The same problem it may be said confronts all periods. True. But the circumstances in which the Greeks approached it were not the same as those in which later times, enjoying the fruits of their labors, have succeeded to it. In the first direction only a beginning had been made, while the second was yet unattempted. To each branch of this task the Greeks brought an especial fitness. The most prominent characteristics of their mind were the instinct of investigation and a genius for form. The first finds its conspicuous development in Socrates, who declared, "*Φιλοσοφοῦντα' με δεῖν ζῆν ἐξετάζοντα ἐμαυτόν τε χαι τοὺς ἄλλους*,"* while both attain their consummate flower in Aristotle. The enthusiasm which came with the birth of philosophy stimulated inquiry in every direction in which truth was likely to be its reward. In the confident words which Bacon used of himself, they "took all knowledge to be their province." They were not content with any one-sided development of a single branch of learning. Older peoples had attained some advancement in special fields of knowledge. The Assyrians, as we shall see, had reaped some results from centuries' study of the stars, and the Egyptians possessed the rudiments of geometry. But the comprehensive intellect of the Greeks proposed to itself as its goal nothing less than the sum of all knowledge.

The genius for form is the germ of that sense of beauty, both real and ideal, which showed itself in every phase of their life, which was the informing spirit alike of their art and of their ethics. This element of order in conjunction with the inspiration of inquiry produced for the first time a philosophic spirit. The results of their investigation were to be compared, digested, systematized. More; facts were no longer the end of their search; they went further and sought principles. It no longer sufficed to ask "*an sit;*" they must know "*cur sit.*" They did not scorn to learn what they might from others; but they seemed to have the power, like the fabled Midas of their own legend, of transmuting all they touched to gold. The scientific method, which appears for the first time with them, was the agent of this alchemy.

While the history of the science of mathematics finds its appropriate point of departure with the Greeks, a study of earlier culture is necessary to an understanding of the state of knowledge at the time their intellectual activity began, and the share in its subsequent development contributed by other nations. Either prior to Greek civilization or contemporary with it and running parallel to it, we may note three early seats of culture from which the outcome of Greek thought was influenced, viz., Babylonia, Egypt, Phenicia. We do not include India in the list, because, while the Hindoos justly claimed a venerable antiquity for their civilization, there was no communion between them and the Greeks until after the conquest of Alexander (325 B. C.), and they made no impress on the mathematics of the West until algebra began to be studied in the middle ages. Each of these countries contained a considerable population, and the first two were the homes of powerful empires.

Movements of population do not occur by chance or at the dictation of caprice; they are determined by causes usually not difficult to discover. Since the unfortunate miss-step—it would be disrespectful to use a harsher word—of our first parents, the chief energies of man have been directed toward an attempt to escape the curse of labor then pronounced upon Adam and his seed. He is ever seeking to live, either by the sweat of somebody else's brow (which is called "genius"), or by as little as possible of his own (which is popularly known as "talent"). The agitation now making by labor organizations looking toward a reduction of the hours of labor is merely a fresh manifestation of a well nigh world-old spirit. People desire, they have always desired, to get a maximum of existence out of a minimum of exertion. Hence in the early days,

"When the world was all before them, where to choose,"

tribal communities would seek for habitations lands in which the climate was least rigorous and changeable, where nature had provided most generously for their herds, and where the soil responded most kindly to tillage. Observe how population tended to settle down into southern peninsulas, as if it were a molten mass operated upon by gravity. The force which was actually at work acted just as surely. It was the attraction of a clearer sky and a more genial sun. The fact, too, that migrating parties found themselves in a kind of *cul-de-sac* with the sea hemming them on all sides but one contributed toward stopping their wanderings. Let us loiter from our subject long enough to say—what may have been stated before—that it may be roughly laid down as a law, not, however, to be too strictly interpreted, that the civilization of a primitive people varies directly as the ratio of their sea coast to the total area of their country. We may cite as examples on the one hand Greece, Italy; on the other, Africa. The reason is not far to seek. Navigation in early times was far in advance of any system of land travel. The sea was a means of communication, connecting, rather than dividing, distant peoples; while those who dwelt far inland were cut off from association with their fellows and failed to get that sharpening of ideas which comes from mental attrition.

In is in accordance with the natural law to which we have referred that the rising of the traditional "curtain of history" discloses the two oldest civilizations flourishing in the rich valleys of the Nile and of the Tigris and Euphrates. The latter district, close to what legend proclaims the cradle of the human family, was at an early date inhabited by a Turanian tribe, akin to the Magyars of Hungary, the Lapps and Finns of the Arctic circle, and the Tartars of the Russian steppes. At first a nomadic people, they became later builders of cities, and excavations in recent years have brought to light interesting specimens of their architecture. Indeed, their architectural propensity is represented as having proved a source of the direst misfortune both to them and the world at large; for on "the plain of Shinar" they essayed to build a heaven-reaching tower, an act of presumption which brought upon them—and us—the confusion of tongues. The name of the place of this unfortunate experiment was Babel (confusion), from which, according to a popular etymology, the name Babylon is derived. The southern branch of this people, the Accads, came in contact with a Semitic tribe who in time became the dominant portion of the mixed population. These were the Chaldeans, from whose chief city, Ur, the biblical records represent Abraham as emigrating to the land of Canaan. To the north, in the higher lands dividing the waters of the great rivers, dwelt a

* I must needs spend my days philosophizing, examining both myself and others.

kindred tribe, the Assyrians, and the history and art and science of the two peoples are closely interwoven. We have spoken of the whole territory as Babylonia for the sake of a single name, but their common learning is more usually styled Assyrian.

The nature of the mental product of these early workers is what might be expected from their habits and environment. Chiefly a pastoral people, they had their wealth in flocks and herds. So we find in Genesis contention arising between the herdsmen of Lot and of Abraham "because the land was not able to bear their flocks." The climate and their occupation made them dwellers in the open air. They learned to guide themselves by means of the stars across the vast level or billowy tracts of land, lying before them like a sea. There were no printed volumes to read, but the newly edited book of nature, in all its freshness, invited and compelled their study. It is not strange that the herdsman, lying on his back, while the cattle grazed, should have attempted to decipher the mysteries of that brilliant page unrolled each night before his wondering vision; that he should learn to look for the coming of the stars as of some distant, supernatural companions, and that from a repeated contemplation of the heavenly bodies he should grow to reverence and adore them as divinities. Thus natural curiosity, material interest, and religious veneration, all conspired to make the Assyro-Babylonians students of the stars, and brought it about that their chief attainments in knowledge were in connection with astronomy. The inception of the study of astronomy occurred among the Accads, to whom their observatories were instruments at the same time of science and of religion. Their successors followed the impetus thus given. The stars were numbered and named, and a chart of the heavens was constructed. A calendar was formed in which the year was divided into twelve months of 30 days each. To supply the deficit from the actual number of days in a year, a month was intercalated every six years, and the priests were charged with the insertion of other months at such periods as were necessary. Eclipses were observed, and a record of them kept. They are said to have invented the sun dial and clepsydra; also the lever and the pulley. The needs of the extended commerce which they gained in later years gave rise to the invention of weights and measures, the origin of which is sometimes attributed to the Phenicians.

The founders of the ancient civilization in the valley of the Nile, it should be scarcely necessary to say, did not belong to the African race. Their own traditions assert them to have been the original inhabitants of their land, but the evidence that they were of Asiatic stock is conclusive. Their language is what is known as a member of the Hamitic family, and bears such an analogy to the Semitic and Aryan tongues as to indicate a relationship, if not a common origin. The Egyptians gloried in the antiquity of their institutions. The darkness from which they emerge into history sheds no ray of definite light upon the steps of their advancement, but the gigantic structures of their erection, standing amid the encroaching sands of the Sahara, are mute but indisputable witnesses of their craft. The gloomy imagination of this venerable people seemed to take a morbid pleasure in its own awe. The inferiority of man to the powers of nature, always borne in so strongly upon dwellers in a tropical region, weighed upon their spirits until whatever by comparison showed the littleness of man, like a basilisk, attracted while it terrified them. The builder's instinct was present in them as in the Assyrians, but the object which they set before themselves was not—as with the Greeks—to please with the beautiful, but to impress with the colossal, the huge, the awe-inspiring. Magnitude of dimension, not grace of outline, was the salient feature of their architecture. The pyramids and the Parthenon tell the whole story of the minds that conceived them. Like the Babylonians, they sought to "unwind the process of the stars," and produced a calendar similar to that of their Semitic kinsfolk. What is most to our purpose, they laid the first few rude stones from which the Greeks constructed geometry.

Sciences are not evolved from the human consciousness by definite design. One does not shut himself up in his study, and say, "I will straightway develop me a science of chemistry, of engineering, of government, or of what not." No; they arise in response to practical necessity, and grow with the extension of experience and of thought in the direction suggested. First the fact, the suggestion, the experiment, it may be; then the theory; when the inductive process has gone so far, deductive demonstration begins, and the united body of truth becomes a science.

Geometry, the first branch of mathematics to be developed, bears in its name the stamp of its practical origin; as it came to the Greeks it was simply "earth measuring." The Assyrians had no geometry because they had no need for it. Occasion did not suggest it. They lived a shifting life, and had practically unlimited territory at their disposal. They were not dependent for subsistence upon any restricted tract of land, and minute questions of boundary and area did not arise. Why measure the earth when each might have as much of it as he chose? But the Egyptians were a vast populace having fixed seats in a narrowly limited country. They maintained themselves by the cultivation of the prolific fields bordering on the Nile; there was but a relatively small quantity of tillable land to be divided among a great number of inhabitants, and considerations of boundary and measurement assumed a vital importance. We translate from Herodotus, who traveled in Egypt about the middle of the fifth century B. C., his account of the origin of geometry. The king referred to was Rameses II, or Sesostris, as he was known to the Greeks, who reigned about a thousand years before the period of Herodotus' travels.

"They (the priests) also said that this king distributed the land among all the Egyptians, giving to each an equal quadrangular portion, and that from this he collected his revenues, requiring the holder to pay yearly rent. If the river, however, cut off a part of any tenant's allotment, he would come to the king and attest the occurrence. The latter would send commissioners to investigate the matter and to measure how much the tract had been decreased, in order that he might pay on the remainder an equitable portion of the prescribed rent. In this way, it seems to me, geometry was invented and passed over to Greece. The sundial, though, and the gnomon, and the twelve parts of the day the Greeks learned from the Babylonians."*

Here, then, among the early Egyptians we find a practical problem giving rise to the first seeds of geometry. These seeds bore no fruit on their native soil because the Egyptian cast of mind lacked the qualities necessary to produce a science. They never advanced beyond the meager rudimentary knowledge, which they possessed as a result of experience and observation, not as a system of demonstrated truth. What they attained, though, is forever notable as constituting the suggestion and an incentive to the geometry of the Greek.

The Phenicians, occupying a narrow strip of sea coast along the most eastern border of the Mediterranean, were a Semitic tribe, related in language and race to the Hebrews and the Assyrians. They were a manufacturing and commercial people, bold, alert, enterprising, in short, the Yankees of antiquity. They made glassware from the sands of the Belus, and extracted from the *murex*, a shell fish found along their coast, a purple dye which they used in coloring the textile stuffs for the manufacture of which they were famous. The exchange of goods brought them into association with the Babylonians, with whom they had an extensive trade by means of caravan, and with the Egyptians. The Phenicians were the earliest navigators; their vessels bore the product of their looms all along the shores of the Mediterranean, and even beyond them, past the pillars of Hercules into the Atlantic, upon which they skirted the western coast of Africa as far south as the Canary Islands, and sailed northward to Cornwall. They exchanged their manufactured articles for the raw products of the peoples with whom they traded. They founded colonies along the northern coast of Africa—chief among these, Carthage—in Sicily, in Spain and elsewhere. It was on a Phenician ship, sailing to the colony of Tarshish, in southern Spain, that Jonah took memorable passage. They came into intimate commercial relations with the Greeks—themselves skilled and adventurous mariners—and profoundly influenced the early Greek culture.

The ancients regarded the Phenicians as great inventors; the arts of manufacture, arithmetic, the invention of weights and measures, and of an alphabet were all attributed to them. More careful investigation has cast a doubt upon their claim to originality. The discoveries ascribed to them seem really to have been borrowed from the Egyptians and the Babylonians. The important work which the Phenicians did in the advancement of civilization was one of distribution. They were the channel through which the influence of the older civilizations was borne to Greece. They stood in this way, to the Egyptians and the Babylonians, in the same relation which, in later times, the Romans held to the Greeks. The former originated; the latter disseminated. Richer than all the precious stuffs of Tyre and Sidon, they bore to the barbaric West the inspiration of a culture destined in fitter hands far to outstrip the achievements of its original. So far the progress in the extension of knowledge was the work of Hamitic and Semitic branches of the Caucasian race; their advance was slow and their labors unfruitful because their learning was a lifeless empiricism. The torch of learning which they bore with but faintly increasing brilliance for centuries, and which lighted only the narrow circle of their personal experience, was soon to be extinguished; but before it expired there was kindled at its flame another, whose transcendent brightness was to illumine all the later course of time. Ethnic and political forces brought the overthrow of the dominion of these once powerful peoples, and the wave of barbarism which submerged them, buried at the same time their civilization. Their part was done; and new hands were to build upon materials first gotten from them a structure of which they had not dreamed. It was the finer, keener intelligence of the Aryan Greeks, acting upon the meager learning of the older Eastern civilizations with which they gained their earliest acquaintance through the Phenicians, that gave the world for the first time a science.

PEANUTS: THEIR GROWTH AND CULTURE.

J. S. Fowler, Virginia.

The so-called "peanut belt" of this country includes a part of the States of Virginia, North Carolina, and Tennessee. Within those limits the peanut is the principal money crop, and in fact there are few farm crops grown, in any part of the United States, that excel it in value per acre.

The first requisite for a crop is good seed. All the nuts retained for that purpose must be kept perfectly dry through the winter, as dampness and fermentation would destroy their germinating power. During wet days, and even in early spring, the farmer and his family are engaged in preparing the seed for planting. Every shell must be opened and the seed extracted. This is termed "popping," and popping bees, to which the neighbors are invited, are frequent. There fun and frolic are rife, as in the corn huskings and apple parings of the more northern States. The cracking of the nuts and of harmless jokes echo from the walls of many an humble cabin. The seed peanuts are all carefully hand picked, and all light colored, shrunken or defective ones rejected, only the plump, perfect peas with unbroken skins being kept for seed. The rejected ones are sold for roasting.

The planting was formerly done by hand in a very tedious and laborious manner. But it is now performed by means of a machine, with which one man can plant six to eight acres per day, in a very superior manner. Though the shelled peanut is nearly the same in size and form as a bean, the same implement cannot be used in planting both. The slightest cracking of the thin pink skin would spoil the peanut for purposes of seed. The peanut planter is very ingeniously constructed to pick up the peas, deposit them at regular intervals in the row, and press the soil down upon them without abrading the tender film in which they are enveloped. Five pecks or twenty pounds of shelled seed are required for an acre. The peanut planting time is from the middle of May to the middle of June.

The most critical time for the crop comes immediately after planting. If the weather is too wet, the seed rots in the ground; if too dry, it withers and perishes. Then the newly planted seed is subject to the depredations of nearly every kind of bird and small animal which inhabits the region. Moles often make great havoc. In nearly all cases more or less of replanting is necessary.

A field of peanuts just sprouting out of the ground is a very pretty sight. The growth is upright until the plant has attained a height of eight or ten inches, then the pea-shaped yellow blossoms appear, and the plant falls over and makes its subsequent growth in a procumbent position. A singular process now ensues. As the petals of the flowers fade and fall, the legumes or pods are forced into the soil, there to complete their growth, and ripen the inclosed seeds, as shown in Fig. 1.

The culture consists in going frequently between the rows with a small plow of peculiar shape. If grass or weeds appear in the rows (all weed growth is called grass in the South), they are cut out with hoes. But after the plants have fallen over, they cover the earth so thickly as to smother out the weeds. A single tap root, which penetrates the earth deeply, like that of the allied red clover, is the main root growth of the peanut plant, of which the scientific name is *Arachis hypogæa*.

Fig. 1.—PEANUT PLANT AND FLOWER.

It is the aim of the peanut grower to have the crop mature about the time of the first frost of autumn. The pods must be lifted from their earthy beds to keep them free from stains. A plow is run under each row, cutting off the main roots and throwing out the pods which adhere to the branches. After they have lain on the ground until partially dried, the whole are stacked in the field. Stout stakes are cut in the forest, the large end sharpened, short strips nailed across them near the sharpened end, and they are then driven into the ground in rows at convenient intervals through the field. The gathered plants are stacked around these stakes, the cross strips being designed to keep them from contact with the ground. Each stack is seven to eight feet high and three to five feet in diameter. Fig. 2 shows a group of them.

The stacks are sometimes hauled to the barn for the purpose of picking the pods; but it is generally done in the field during the autumn and winter. The pickers build small fires, around which they gather, picking off the nuts and sorting the well filled ones from the "pops" as the partially empty pods are called. Efforts have been made to devise machinery for picking the nuts from the vine; but without success as yet. The vines, after being stripped of the nuts, make a forage nearly equal to clover hay, save for the adhering sand and dirt, and stock of all kinds eat it greedily.

After the haulm and nuts are all cleared away, a second crop remains below the surface. This is harvested by swine, which are turned in for the purpose. They turn the soil upside down in search of the toothsome nuts, and however lean the pig may be when it goes in, it soon becomes very fat. The pork of these hogs, though it has a sweet nutty flavor, is rather soft unless they are finished off with corn before slaughter.

The market for peanuts was formerly controlled wholly by the middlemen, who generally held liens on the crop before it was harvested, for advances made to the farmer. They were never slow to enforce their liens; but came early and took them, so that any future enhancement in price accrued to their benefit, and not the farmer's. But the Farmers' Alliance has changed all that. It stands ready to take the product of the farmer's toil, store it for him, and advance money for immediate necessities. By the aid of the Alliance the producers can fix a price which will at least prove fairly remunerative. The nuts are kept out of the hands of speculative middlemen, and sold directly to dealers at the principal distributing points. They were formerly reluctant to deal directly with producers; but last year they sent their agents into the producing territory to buy freely of the Alliance, whose managers fixed the price.

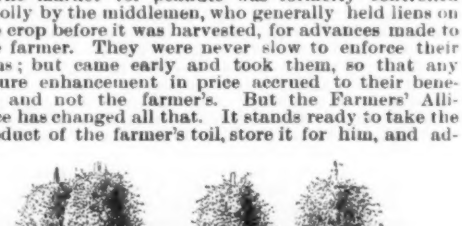


Fig. 2.—PEANUT STACKS.

A bushel of peanuts in the shells weighs twenty-two pounds, and they are put in bags holding one hundred pounds each. At six cents per pound, the price at which the bulk of last year's crop was sold, a load represents quite a nice sum of money. On a farm adjoining that of the writer, a crop of one hundred and fifteen bushels per acre was harvested last year. But this is very far above the average, which may be

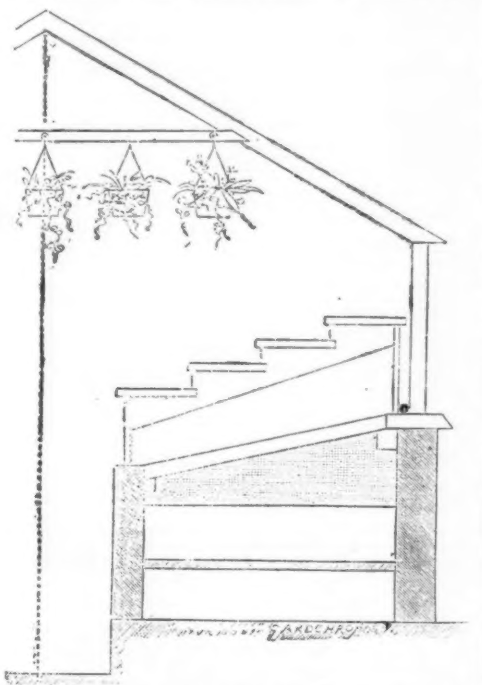
* Herodotus, Book II, c 109.

placed at twenty-five bushels per acre. A larger acreage has been planted this year than ever before, some growers having one hundred and fifty acres each. If the crop is a good one, it will tax the resources of the "Union" to the uttermost.—*American Agriculturist.*

A NEW ARRANGEMENT FOR USE IN GREENHOUSES.

IN the nursery of M. A. D'Haene, of Ghent, may be seen a new arrangement of the staging, which is worth notice. On each side of the path, which divides the house longitudinally into two equal parts, there is placed a propagating case, devoted to the propagation and germination of plants, and covered by lights which can be pushed away when necessary. Above these cases is an arrangement of stages, on which plants may be placed; these stages are also on rollers, and may be moved aside when it is necessary to work at the case beneath, or when the plants upon them have to be changed. Behind these stages, the glass side of the house, three feet deep, permits the entrance of sufficient sunlight to the frame, so that cuttings can be taken, and seeds, especially those of palms, may germinate. The results which the inventor of this system has obtained so far are most satisfactory.

At the top of the house, the small beams are strengthened by horizontal iron bars, from which orchids, nepenthes, etc., may be hung; in a word, there are, as it were, three tiers, one devoted to the germination and propagation of seeds and plants, another for growing plants, and lastly one for specimens which require to be suspended in baskets or little wooden rafts.



PROPAGATING PIT BENEATH MOVABLE STAGE.

The illustration shows this convenient arrangement. —*The Gardeners' Chronicle.*

ON THE COLORING REAGENTS OF THE FUNDAMENTAL SUBSTANCES OF VEGETABLE MEMBRANE.

By M. L. MANGIN.

THE use of coloring matters in vegetable anatomy has not formed hitherto the subject of methodic investigations. Although the list of reagents used in microscopical studies grows daily, the absence of precise data on their composition, their chemical properties, and the conditions of their action renders the verifications of the results announced very much a matter of chance.

In the researches which the author has undertaken he has proposed to compare the action of the coloring matters with their composition, and to verify analytically the results obtained with coloring reagents. He believes that by defining strictly the nature and the *modus operandi* of these reagents, it will be possible to arrive at a method for the qualitative micro-analysis of the tissues capable of superseding the empirical processes of coloration now used.

In this memoir he concerns himself merely with the fixation of the coloring reagents on the fundamental substances recognized in the so-called cellulosic membrane of plants, this fixation taking place without mordants in a neutral, alkaline, or acid medium.

The various coloring matters of the aromatic series may be divided into two categories: the one is formed of compounds in which a basic coloring matter is united to various acids, mineral or organic; the other is formed of acid colors employed in the state of alkaline salts.

The substances of the first class fix themselves with a variable energy upon the pectic compounds, and thus manifest the acid function of the compounds. They color neither callose nor cellulose. The author mentions the *azo group, e. g.*, Vesuvian brown and chrysoidine; the *diphenylmethane group, e. g.*, auramine; the *triphenylmethane group*, such as Victoria blue, night-blue, magenta, Paris violet; then all the colors of the *oxyazine group*, as naphthylene blue, Nile blue; of the *thiosine group*, methylene blue; of the *eurhodine group*, neutral red; of the *saffranine group*, neutral blue, phenosaffranine, Magdala red, etc. The affinity of these colors for the pectic compounds is very unequal and feeble, as the presence of an excess of acid or glycerin is sufficient to decolorize the tissues more or less quickly.

The second class, formed of the alkaline salts, contains a number of substances which never color the pectic compounds, but many of them fix upon cellulose and callose, proving the basic nature of these bodies. In this class we have an interest only in two groups, the azo group and the triphenylmethane group.

The azo group, if we set on one side chrysoidine and Vesuvian brown, is chiefly formed of alkaline salts, among which we distinguish three important types.

The first type comprises the coloring matters which only contain one azo group, such as xylidine ponceau, the composition of which is:

$$C_6H_3\begin{cases}(CH_3)_2\\N{=}N{-}C_{10}H_4\end{cases}\begin{cases}(\beta)OH\\(SO_3Na)_2\end{cases}$$

To this type belong aniline and toluidine ponceau, naphthorubine, etc., and the tropeolines. These substances color the protoplasm yellow, but they have no action upon cellulose or callose.

The second type is formed of substances containing two azo groups, such as orchil red A.

$$C_6H_3\begin{cases}(CH_3)_2\\N{=}N{-}C_6H_2\end{cases}\begin{cases}(CH_3)_2\\N{=}N{-}C_{10}H_4\end{cases}\begin{cases}\beta OH\\(SO_3Na)_2\end{cases}$$

Here belong orselline BB, azorubine, naphthol black, the croceines, etc. The substances color cellulose in a neutral or faintly acid bath, and have no action upon callose.

The third type contains coloring matters of the benzidic series, such as Congo red:

$$C_6H_4(_4){-}N{=}N(b)C_{10}H_5\begin{cases}(a)NH_2\\(a)SO_3Na\end{cases}$$

$$C_6H_4(_4){-}N{=}N(b)C_{10}H_5\begin{cases}(a)SO_3Na\\(a)NH_2\end{cases}$$

To this type belong Bordeaux extra, Congo G R, Congo-corinth, delta-purpurine G, brilliant Congo G, resulting from the action of the sulphur compounds of naphthol upon benzidine; azo blue, the Congo-corinth B, the benzo-purpurines, the rosazurines, where toluidine is substituted for benzidine, azo violet, benzoazurine, heliotrope, where dianisidine is substituted for benzidine, etc. These coloring matters, which are ordinarily precipitated by acids, dye cellulose and callose directly in a neutral or feebly alkaline bath.

The triphenylmethane group does not offer such definite relations between the coloring power and the chemical compositions. We distinguish here first a great number of bodies formed of hydrochlorates, sulphate, etc., which dye the pectic compound directly, and then a series of alkaline salts which we divide into three groups. The first group includes acid magenta, acid violet, Bayer's blue, Nicholson blue, etc., resulting from the respective action of sulphuric acid upon magenta, Paris violet C B, diphenylamine blue, or aniline blue. These substances do not color cellulose, but some of them, as the soluble blues, and especially Bayer's blue, color callose. The colorization is the more active as the sulphurization is more complete; thus 6 B blue, a mixture in which trisulphonated triphenylrosaniline predominates, is the most active of the soluble blues.

The second triphenylmethane group is formed of the alkaline salts of rosolic acid, which dye callose and cellulose directly.

The third group is formed of eosines, a salt of fluoresceine, such as eosine, erythrosine, phloxine, which color nitrogenous matters strongly, but do not attach themselves to callose or cellulose.

The manipulative details will be described in a future communication.—*Comptes Rendus; Chem. News.*

BLEACHING WITH SODIUM HYDROSULPHITE.

By G. DOMMERGUE.

THE bleaching process with sodium hydrosulphite, which has been industrially employed since 1883, yields excellent results, but, as is also the case with bleaching by sulphurous acid, the fibers thus bleached are unfit for dyeing. For the production of hydrosulphite about 300 lit. sodium bisulphite 35–40° Be. are put into a pine wood tub of 500 lit. capacity, to which scraps of pure zinc are added until they reach the surface of the liquid (the volume of metal must not be more than ⅛ of the total volume), when the tub is covered up. In order to prevent a too high temperature, earthenware tubes are inserted into the tub, in which cold water circulates. After 1 hour the liquid is drawn off into a tub which is always to be kept full, covered and allowed to stand for 12 hours, when an abundant amount of zinc sodium sulphite has crystallized out. The remaining liquid portion is the bleaching agent. As the latter by the contact with the air is apt to be converted into sodium bisulphite with rising temperature, the tubs for the production of hydrosulphite, as well as for bleaching with it, must always be kept as full as possible and carefully covered.

For bleaching the material is first well cleaned, *i. e.*, treated with sodium carbonate and then with soap, and entered into a 1,000 lit. tub containing a mixture of the bleaching liquid with an equal volume of water, taking care that the tub is nearly filled. After standing covered for 6 hours the yarn is well wrung and piece goods passed through pine wood squeezers above the tub. Then the material is at once washed in filtered water; if this washing is delayed the fibers are, by the contact with the air rapidly heated up to 70–80°, and largely altered. Sometimes goods thus bleached after finishing show stains which are attributable to remnants of zinc sodium sulphite. They are removed by passing the pieces through a cold, very weak bath of hydrochloric acid and washing in abundant water.

With one single bleaching tub 3,000 pieces of woolen goods at 100 m. each, *i. e.*, about 36,000 kil. wool, can be bleached per year. About 100 kil. zinc serves for several years, because the undissolved metal can be rendered serviceable for further use by washing it with abundant water which is feebly acidulated with hydrochloric acid. The price of bisulphite is about 25 fr. ($5) per 100 kil. When the bath falls below its original level, it is filled up with dilute hydrosulphite, whereby the strength of the bleaching bath is preserved for almost an unlimited period. In a tub of 1,000 lit. capacity about 130 kil. wool can be entered at a time, the cost amounting to about 1·36 fr. (about 26 cents) per 10 kil. fiber. The simple and cheap process, which is in some factories worked since several years, is probably destined in no distant time to supersede the ordinary bleaching methods.—*Chem. Ztg.*

ACTION OF THE CHLORIDES OF CALCIUM AND MAGNESIUM UPON COTTON.

THE use of these chlorides is now so common in the preparation of sizes for finishing cotton goods that the following observations of Grimshaw are of great importance and will, perhaps, explain the deterioration which has been lately sometimes observed in cottons. "It is not a new observation that, when the chlorides of calcium and magnesium are heated in contact with air, a portion of this chlorine is given off. In view of the very large quantities of both these substances used in the sizing and finishing of cotton and other goods, it is evident that it is of considerable interest and importance to define at what temperature, at how low a temperature, in fact, and to what extent, the decomposition of these salts proceeds, because, if the chlorine is liberated at temperatures to which it is at all likely that the fabrics containing them may be subjected under the ordinary conditions of their use and manufacture, then the chlorine, or resulting hydrochloric acid, will be certain to cause more or less deterioration of the fabrics.

"We know that at a red heat the chloride of calcium becomes alkaline to litmus, and that, at temperatures considerably lower than this, the chloride of magnesium parts with an appreciable amount of its chlorine. Recently, several cases of deterioration of the strength of cotton fabrics have been traced to the action of chloride of magnesium, and we may take it, I think, as an undoubted fact, that this 'tendering' of the cotton fiber in such fabrics is due to the action of the hydrochloric acid formed by the decomposition of the chloride. I am making an attempt to define, with accuracy, the lowest limit of temperature at which the decomposition of the chloride of calcium and magnesium, and, incidentally, the chloride of zinc, takes place; the extent of the decomposition, and the influence that time, and the presence of moisture, have upon this, and I am able to give some figures which, though only of a preliminary nature, are of interest on some of these points." These few preliminary experiments would appear to establish the fact that, at any temperatures which can possibly prevail in the manufacture or use of goods containing the calcium chloride, this salt is perfectly stable, and no fear of deleterious action need be entertained, while the reverse in the case with the magnesium chloride. The figures for the latter show that this salt is decomposed comparatively readily at a low temperature: a temperature of 117° C. is one which, in some operations, the fabric may easily attain, and it would appear likely that an even lower temperature may effect this.—*Jour. Soc. of Chem. Industry.*

SULPHONAL, PARALDEHYD AND CHLORALAMIDE.

THE Therapeutic Committee of the British Medical Association has drawn up a report as to the comparative utility of different hypnotics. The points especially dealt with are (*a*) the doses of the drug given; (*b*) whether sleep is produced with certainty, how soon it comes on, and how long it continues; (*c*) the production of dangerous or other disagreeable effects; and (*d*) whether the drug loses its effect. The following is a summary of results obtained with sulphonal, paraldehyd and chloralamide:

Sulphonal.—1. *Dose.*—In thirty-two of the cases recorded, 20 grains was given in eleven instances, once at night. Sleep came on in half an hour to three hours, in one case in five hours, and in another in nine hours. A second dose on the succeeding night in one case produced sleep in five minutes. Sleep lasted in four cases all night; in four cases six hours; and in three cases one to two hours. With 25 grains (four cases) sleep came on in two hours and lasted six hours or all night. With 10 and 15 grains there was less sleep produced, and in a case of pneumonia (15 grains) there was no sleep after the drug. The few cases (seven in all) in which 35, 40 and 60 grains were given showed that these doses did not possess greater hypnotic effect than a dose of 20 grains. In a case of chronic gout 30 grains had no effect.

Disagreeable After-Effects.—In six out of ten cases in which 20 grains had been given, disagreeable after-effects were noted. Drowsiness next day was noted six times; giddiness four times; and headache and inco-ordination of gait each twice. In four cases where 10 grains had been given, drowsiness was noted once; in five cases with 15 grains drowsiness was noted twice and giddiness twice; with 25 grains (four cases) drowsiness was noted twice, giddiness once, headache once. In seven cases, with 30 to 60 grains, drowsiness was noted four times, giddiness twice, headache twice, inco-ordination of gait and vomiting each once.

Whether the Drug Loses its Effect?—Several of the cases showed that a second dose on the succeeding night has a greater effect than on the first night. Thus, in one case, 20 grains produced on the first night two hours' sleep with no bad after-effects; on the second, a similar dose produced eight hours sleep with drowsiness, giddiness, and inco-ordination of gait on the following day. In some cases prolonged use of the drug appears to diminish its effect. Thus, in one case (asthma and bronchitis) 20 grains was given every other night for eight weeks. During the first fortnight sleep came on in an hour and lasted twelve hours each night. The drug was then omitted for a week, when the insomnia returned. In the succeeding five weeks the drug, after three hours, produced six hours' sleep. In a case of phthisis 20 grains was given every other night for twenty-six days, except for five days, when the dose was reduced to 10 grains, but afterward was increased. During the time the patient was taking 20 grains, after an hour he slept for four to six hours. The drug was omitted for a fortnight, and, on recommencing it, it produced only drowsiness, and no sleep. In a case of neurasthenia and insomnia, quoted by Mr. Priestley, sulphonal, 10 to 20 grains, did not lose its effect during six months.

Paraldehyd.—Single doses of 40 to 60 minims (fourteen cases) produced sleep in five to fifteen minutes; in two cases in half an hour; in one case in an hour. In most cases the sleep was wakeful and restless, and lasted very varying times, in one case only three-quarters of an hour, in another case there was restless dozing for three hours, in another sleep for two hours; in ten cases sleep lasted from three to six hours, and in one case sleep for twelve hours. These results refer to single doses. Half a drachm every three hours produced within half an hour two hours' sleep; 20 minims every four hours for fourteen days produced better sleep at night, but not during the day.

Disagreeable After-Effects.—Giddiness and drowsiness were noted each once, vomiting three times, and retching and nausea each once.

Tolerance of the Drug.—In a case of mitral stenosis on two nights 40 minims gave two to five hours' sleep; on the third night a similar dose had no effect; on the fourth night 1 drachm was satisfactory, but on the sixth night it produced no effect. When the paraldehyd failed, it seemed to produce slight excitement. Morphine succeeded well afterward.

Chloralamide.—In one case 20 grains, and in six cases 30 grains, were given in single doses. After the 20 grains sleep came on in twenty minutes and lasted three hours, with half an hour's interval of waking; after 30 grains, sleep came on in fifteen minutes to half an hour (four cases), one to two hours (two cases). Sleep lasted all night in three cases, in two cases four to five hours, and in one case there was two hours' dozing, then an interval of wakefulness, and then two hours' sleep.

Disagreeable After-Effects.—None observed.

Tolerance of the Drug.—Thirteen consecutive observations were made in a case of pernicious anemia, with several weeks' insomnia. Thirty grains of chloralamide failed once on the ninth night; on the other nights the drug produced, in one to two hours, restless sleep, lasting all night, with two or three short intervals of wakefulness.

THE ACTION OF SULPHUR CHLORIDE ON OILS, ETC.

By THOMAS T. P. BRUCE WARREN.

IN examining samples of so-called lard and lard oil, I have felt surprised at the small yield of soluble matter from the coagulum produced by sulphur chloride.

Lard and lard oil, when genuine, yield products which are perfectly soluble in carbon disulphide; so that, if we operate on a mixture consisting of equal parts say cottonseed oil and lard oil, *ut supra*, we may reasonably expect about 50 per cent. soluble matter.

The adhesion of the lard oil, or retention by imprisonment among the particles of altered cotton oil, reduces the apparent yield as regards lard oil, and increases that of cotton oil. Fortunately, in examining mixtures of this kind I have invariably confirmed the analytical result by synthetical experiment.

Instead of treating a clammy soft coagulum with carbon disulphide, it is better to treat the same with a moderately strong alkaline solution containing about 30 per cent. KHO.

The results obtained are in direct contradiction to a statement in Watts' "Dictionary," article linseed oil, vol. iii., p. 708. It is there stated that "on mixing from 15 to 25 parts chloride of sulphur with 100 parts linseed oil, caoutchouc-like products are obtained, which are harder the more chloride of sulphur they contain, and are not attacked by moderately dilute acids and aqueous alkalies, but *are ultimately saponified by concentrated alkalies.*"

When a very concentrated solution is used, the coagulum, even on long boiling, does *not dissolve*, but a slimy, gelatinous mass is formed.

A mixture of cotton oil and lard oil, when treated with sulphur chloride, may be almost unmanageable to deal with in the ordinary way, but if boiled with a strong alkaline solution for some time it completely disintegrates, leaving the insoluble portion of the coagulum colorless by repeated washings on a filter, until alkaline reaction ceases. If a non-saponifiable product from lard or lard oil be formed, it can easily be removed by means of ether.

By adding an acid to the filtrate the fatty acids are separated out. The glycerin determination and the properties of the fatty acids will furnish a clew as to the oils which are present, and do *not* yield solid and insoluble products in carbon disulphide.*

The following singular result was met with a few days ago, which confirms the value of this procedure. A mixture was made of cotton and lard oils, which did not yield an insoluble product. It dissolved with slight cloudiness in CS_2. This was evaporated and the residuum treated by the saponification process, when the altered cotton oil was readily separated from the saponified oil. This singular result shows that, although an oil or fat may be present in a mixture which prevents the appearance of an insoluble substance in CS_2, we can recover the same if present by saponification. An oil which is, in the ordinary way, acted on by sulphur chloride may be prevented from revealing itself in consequence of the solvent action of other oils present, but although this singular event may happen, it establishes the fact that the reaction has taken place, although the expected coagulum did not appear.

I hope to return to the consideration of this interesting reaction at an early date, with special reference to lard oil and lubricating mixtures.

Some very important results have been obtained on the synthesis of the fatty glycerides, arising from the analysis of mixtures of oils. How far it is possible to confirm Berthelot's observations on the synthesis of oils I can scarcely say. But this fact is certain, we can reproduce from the fatty acids of cotton oil and glycerin a compound closely approaching the original cotton oil. The salient points are, that the purified acids from cotton oils do not yield insoluble products with sulphur chloride, but by treating these acids with glycerin in stout hermetically sealed glass tubes at a temperature of about 500° F. for several weeks, we confirm the reproduction of cotton oil. Hence the fatty glycerides are concerned in the reaction due to sulphur chloride, at least in the case of cotton oil.

An interesting application of this part of the process is to reproduce from a sample of blown oil, recovered from a petroleum mixture, the original glyceride, and to establish whether the blown oil used was that of cotton oil or rape oil.

I can now understand why it is that sulphur chloride produces dark and even black products from oxidized oils. It is due, no doubt, to the removal of glycerin. The stability of the fatty glycerides in different oils is one of very great importance, and has more to do with the drying qualities of an oil than seems to be taken account of.

The iodine absorption of an oil, before and after exposure to the air in a warm place in vessels, so that the weight of oil and area of surface are identical, will give a very accurate idea of the changes brought about by oxidation. Poppy oil behaves so exceptionably in this respect to other oils that by exposure in an open dish at 140° F. its iodine absorption fell from 135 per cent. to 119 per cent. in ten days. Rape oil similarly exposed became very much bleached, but fell only about 10 per cent.

A deduction which can hardly be overestimated in its importance to the chemistry of oils is that so long as we do not upset the chemical composition of the proximate principles of an oil, we can reproduce that oil, and, further, a glyceride already containing a certain proportion of an acid may be made to take up, if not previously saturated, a further proportion of that acid. This fact receives a significance when we consider the relation of cocoanut oil and butter fat so far as concerns the volatile acids.—*Chem. News.*

* The glycerin determination is made on the soluble portion recovered from the coagulum.

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